PRELUDE FLNG

ENVIRONMENT PLAN
2020

Prelude FLNG Environment Plan

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Ver.	**Change Description**	**Date**	**Originator**	**Reviewed by**	**Approved by**
1	Issued for Review	23/04/2015	Environment Advisor (Project)	Prelude Technical HSE Lead Prelude HSE Manager Prelude OIM Logistics Manager Environment Manager Services Coordinator Commissioning Leads Subsea Engineer HSSE Advisor Wells Manager Start Up Process Engineer External Affairs Advisor	Prelude Project Director
2	Issued for Review	12/06/2015	Environment Advisor (Project)	Ver.1 reviewers plus the following: Prelude Asset Manager Prelude Project Director Prelude Production Manager General Manager HSSE Construction Manager Process Surveillance Lead Production Chemistry Lead	Prelude Project Director
3	Issued for Review	15/09/2015	Environment Advisor (Project)	Prelude Technical HSE Lead	Prelude Project Director
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REVISION HISTORY					
Ver.	**Change Description**	**Date**	**Originator**	**Reviewed by**	**Approved by**
				Environment Technical Authority	
8	Approved for Review (incorporated EP Changes: MEG, MBP, Boiler Blowdown, STP, Chemicals, Smokeless Flare, updated IMS residual risk assessment)	20/12/2018	Prelude Environment Engineer Shell Australia Environment Advisor	Startup Manager Prelude HSSE Manager Prelude Technology Manager Prelude Production Manager QMI Engineer Startup Process Engineering Lead Start up Process Engineer	Prelude Asset Manager
9	Approved for Use prior to SURU	21/12/2018	Prelude Environment Engineer Shell Australia Environment Advisor	Startup Manager Prelude HSSE Manager Prelude Technology Manager Prelude Production Manager QMI Engineer Startup Process Engineering Lead Start up Process Engineer	Prelude Asset Manager
9.1	Approved for Review for formal EP resubmission	2/10/2019	Prelude Environment Engineer Shell Australia Environment Advisor Environment Consultant	Offshore Installation Manager Maintenance Manager Snr Process Engineer 3x Design Process Engineer Production Coordinator Services Coordinator Production Chemist Snr Instrument Engineer Principal Environment Advisor Emergency Response Coordinator Head of Marine HSSE Advisor External Relations Advisor Snr Legal Counsel	
10	Approved EP resubmission for NOPSEMA Assessment	6/2/2020	Prelude Environment Engineer Shell Australia Environment Advisor	External Relations Advisor	Prelude Asset Manager

REVISION HISTORY					
Ver.	Change Description	Date	Originator	Reviewed by	Approved by

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 Environment Plan Summary Statement

This Prelude Environment Plan (EP) summary has been prepared from material provided in this EP. The summary consists of the following as required by regulation 11(4):

EP Summary material requirement	Relevant section of EP containing EP Summary material
The location of the activity	6.2
A description of the receiving environment	7.0
A description of the activity	6.0
Details of the environmental impacts and risks	9.0
The control measures for the activity	9.0
The arrangements for ongoing monitoring of the titleholders environmental performance	10.4.1
Response arrangements in the oil pollution emergency plan	9.14
Consultation already undertaken and plans for ongoing consultation	5.0
Details of the titleholders nominated liaison person for the activity	10.5.5

2.0 Introduction

Shell Australia Pty Ltd (Shell) operates the Prelude Floating Liquefied Natural Gas (FLNG) Project (EPBC 2008/4146) in the Petroleum Permit Area WA-44-L (Figure 2-1). Prelude is located in Commonwealth marine waters in the northern Browse Basin, 200km offshore northwest Australia and 460km north-north east of Broome. Shell is the Titleholder and Operator of Prelude FLNG in joint venture with INPEX, KOGAS and OPIC.

The Prelude FLNG Project comprises the FLNG facility itself and subsea systems including: production wells and manifolds; flowlines; riser base manifolds; flexible risers that transport the gas, condensate and any produced formation water to the FLNG facility; and umbilicals used to control the wells and associated equipment (Figure 2-1).

The entire Prelude FLNG Project was referred by Shell under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 which is further addressed in Section 3.1.2.

Environmental management for the Prelude FLNG is undertaken in agreement with this EP, which was prepared in accordance with the requirements of the Prelude FLNG Project (EPBC 2008/4146) Conditions of Approval (see Section 3.1.2) and the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E) Regulations*), and describes the following:

- Shell's Health, Security, Safety and Environment and Social Performance (HSSE and SP) Commitment and Policy and the environmental performance objectives that derive from the Policy
- The consultation process undertaken with the Relevant Persons and the associated resolution of and/or responses to any objections or claims
- The area of operations, the proposed activities and its expected time frame
- The environmental management framework for the activity including legislation and other requirements
- The existing physical, natural, social and economic environments of the region, including issues or sensitivities particular to the activity
- The impacts and risks to the environment from both planned (normal) and unplanned (abnormal) operations
- The Environmental Performance Outcomes, Standards and Measurement Criteria against which environmental performance is measured
- The Implementation Strategy, including key roles and responsibilities that are employed to achieve the program's environmental performance goals[1]
- A system for documenting, monitoring, reporting and reviewing the success of the Implementation Strategy to facilitate improvement of environmental performance and external reporting as required.

[1] The Prelude FLNG Oil Pollution Emergency Plan (OPEP) (HSE_PRE_013075), APPEA OSMP Framework and the Operational and Scientific Monitoring Bridging Implementation Plan (HSE_PRE_016370) are presented as standalone documents, submitted together with this EP.

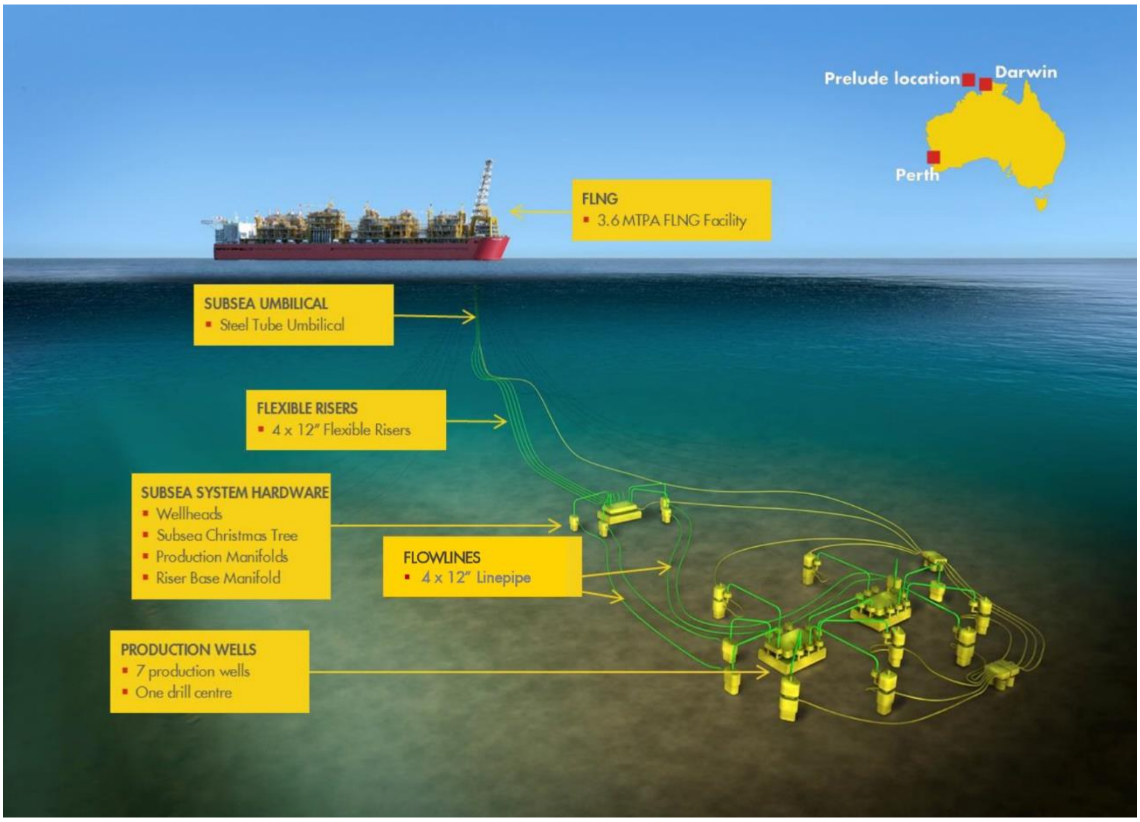


Figure 2-1: Prelude FLNG and Associated Subsea Infrastructure Schematic

3.0 Requirements

This section is intended to fulfil the requirements of Regulation 13 (4) of the OPGGS(E) Regulations and meet NOPSEMA's expectations stated in the Environment Plan Content Requirements Guidance Note (2019). Regulation 13 (4) – Requirements of the OPGGS(E) Regulations stipulates that an EP must:

> *"(a) describe the requirements, including legislative requirements, that apply to the activity and are relevant to the environmental management of the activity; and*
>
> *(b) demonstrate how those requirements will be met*."

The Environment Plan Content Requirements Guidance Note (NOPSEMA 2019a) provides additional information on NOPSEMA's expectations of EP content relating to Regulation 13 (4). NOPSEMA does not expect that requirements that are not relevant to the environmental management of petroleum activities be included in the EP.

This section contains the following, which are intended to meet the requirements stated above:

- Legislation (including the EPBC approval conditions applied to the Prelude FLNG project)
- Standards and guidelines
- International agreement and conventions.

3.1 Legislation

This section describes the Australian legislation that is applicable to the environmental management of the petroleum activities within the scope of this EP. The name of each piece of legislation is provided, along with a description of its relevance to the petroleum activities. A link to the section of the EP related to how these legislative requirements have been considered is also provided.

As the planned activities considered in the EP take place entirely in Commonwealth waters, legislation relating to the environmental management of the petroleum activities considered in this EP are primarily Commonwealth Acts and subsidiary legislation. Key Acts include the Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Cth) (OPGGS Act) and the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act). These Acts and subsidiary legislation are discussed in Sections 3.1.1 and 3.1.2 respectively; additional Commonwealth legislation is considered in Section 3.1.3.

Large volume unplanned hydrocarbon releases may under some circumstances impact upon the environment within the jurisdiction of the State of Western Australia. Western Australian legislation that may be applicable to the environmental management of such hydrocarbon releases has also been considered in Section 3.1.3.

3.1.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The OPGGS Act provides the regulatory framework for petroleum exploration, production and greenhouse gas activities in Commonwealth waters. The OPGGS Act is supported by a range of subsidiary legislation, including:

- the Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 which ensure that facilities are designed, constructed, installed, operated, modified and decommissioned in Commonwealth waters only in accordance with Safety Cases that have been accepted by NOPSEMA
- the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 which require that a Well Operations Management Plan (WOMP) are assessed and accepted by NOPSEMA for existing or proposed offshore facilities
- the OPGGS(E) Regulations 2009 (Cth).

Of particular relevance to this EP are the OPGGS(E) Regulations 2009, which require the environmental impacts and risks of offshore petroleum and greenhouse gas storage activities be managed to a level that is acceptable and ALARP. The OPGGS(E) Regulations 2009 are discussed further below.

3.1.1.1 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations

The OPGGS(E) Regulations 2009 provide for the protection of the environment in Commonwealth waters by requiring that petroleum and greenhouse gas storage activities be managed in a way that:

- reduces the environmental impacts and risks of the activity to a level that is ALARP
- reduces the environmental impacts and risks of the activity to an acceptable level
- is consistent with the principles of Ecologically Sustainable Development (ESD), as defined in section 3A of the EPBC Act, which includes:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
- if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
- improved valuation, pricing and incentive mechanisms should be promoted.

The methodology applied to assess environmental impacts and risks from the petroleum activities considered in this EP details how impacts and risks are managed to a level that is acceptable, ALARP and consistent with the principles of ESD. This methodology is described in Section 8.0 and Sections 9.1-9.2, with aspect-specific demonstrations provided in each of the impact and risk assessment in Sections 9.3-9.14.

Regulation 13(3) of the OPGGS(E) Regulations 2009 requires EPs to consider Matters of National Environmental Significance (MNES) protected under the EPBC Act, including the following:

- the world heritage values of a declared World Heritage property within the meaning of the EPBC Act
- the national heritage values of a National Heritage place within the meaning of that Act
- the ecological character of a declared Ramsar wetland within the meaning of that Act
- the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act
- the presence of a listed migratory species within the meaning of that Act
- any values and sensitivities that exist in, or in relation to, part or all of:
  - a Commonwealth marine area within the meaning of that Act
  - Commonwealth land within the meaning of that Act.

MNES that may credibly be impacted, or are at risk of being impacted, are described in Section 7.0 and are considered in the assessment of environmental impacts and risks.

Regulation 10A of the OPGGS(E) Regulations 2009 states the criteria for acceptance of an EP. These are summarised in Table 3-1, along with the sections of this EP that relate to each of the criteria.

Table 3-1: Relationships between OPGGS(E) Regulation 10A requirements and EP sections

OPGGS (E) Regulation	Requirement	Relevant Section of EP
10A (a)	The EP is appropriate for the nature and scale of the activity	Section 6.0 and Section 12.0 detail the nature and scale of the petroleum activities considered within this EP. Section 7.0 describes the environmental receptors that may credibly be impacted,

OPGGS (E) Regulation	Requirement	Relevant Section of EP
		or are at risk of being impacted, by the planned and unplanned activities. Section 9.3 to Section 9.14 provides the environmental impact and risk assessments based on the context provided by Sections 6.0, Section 7.0 and Section 12.0 (as well as Shell's internal context and the context provided by Relevant Persons).
10A (b)	The EP demonstrates that the environmental impacts and risks of the activity will be reduced to ALARP	Section 9.1 to Section 9.2 details the method by which Shell demonstrates environmental impacts and risks are managed to a level that is ALARP. Aspect-specific ALARP demonstrations are provided in the impact and risk assessments provided in Section 9.3 to Section 9.14.
10A (c)	The EP demonstrates that the environmental impacts and risks of the activity will be of an acceptable level	Section 8.0 details the method by which Shell demonstrates environmental impacts and risks are managed to a level that is acceptable. Aspect-specific demonstrations of acceptability are provided in the impact and risk assessments provided in Section 9.3 to Section 9.14.
10A (d)	The EP provides or appropriate environmental performance outcomes (EPOs), environmental performance standards (EPSs) and measurement criteria (MCs)	EPOs, EPSs and MCs are detailed in Section 9.3 to 9.14.
10A (e)	The EP includes an appropriate implementation strategy and monitoring, recording and reporting arrangements	The implementation strategy for the EP is provided in Section 10.0.
10A (f)	The EP does not involve the activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, being undertaken in any part of a declared World Heritage property within the meaning of the EPBC Act.	Section 6.0 and Section 12.0 detail the planned petroleum activities considered in this EP, none of which will occur within a World Heritage Area.
10A (g) (i) & 10A (g) (ii)	The EP demonstrates that: (i) the titleholder has carried out the consultations required by Division 2.2A; and (ii) the measures (if any) that the titleholder has adopted, or	The consultation undertaken in relation to the EP are detailed in Section 5.0, including Shell's responses to any claims or objections made by Relevant Persons. Any management measures adopted in response to stakeholder consultation

OPGGS (E) Regulation	Requirement	Relevant Section of EP
	proposes to adopt, because of the consultations are appropriate	outcomes are considered in the aspect-specific impact and risk assessments in Section 9.3 to Section 9.14.
10A (h)	The EP complies with the Act and the regulations.	Section 3.1.1 (i.e. this section) shows the relationship between the Act, regulations and components of the EP.

3.1.2 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act and supporting regulations provide for the protection of the environment and the conservation of biodiversity in Australia. Amendments to the OPGGS Act and OPGGS(E) Regulations 2009 in February 2014, undertaken as part of the streamlining of environmental approvals for petroleum activities in Commonwealth waters, require impacts and risks to matters protected under Part 3 of the EPBC Act (i.e. MNES) be considered in the EP. Following the streamlining arrangements, NOPSEMA became the sole environmental regulator for petroleum activities (i.e. regulates activities under the OPGGS Act and EPBC Act) in Commonwealth waters.

The matters protected under Part 3 of the EPBC Act that are required by the OPGGS(E) Regulations 2009 are outlined above in Section 3.1.1.1 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations. As part of the streamlining arrangements, matters protected under Part 3 of the Act must be considered by NOPSEMA when assessment an EP.

3.1.2.1 Consolidated Approval Conditions

The Prelude FLNG Project was referred for assessment under the EPBC Act in 2008 (EPBC 2008/4146) and was deemed to be a ‘controlled action’. The Project was assessed through an Environmental Impact Statement (EIS), following which the Project was approved on 12 November 2010 subject to a series of conditions via approval decision EPBC 2008/4146. These conditions were varied on 8 September 2015 and the consolidated approval conditions subsequently published. The consolidated conditions, along with the associated sections of the EP relevant to the conditions, are provided in Table 3-2.

Table 3-2: EPBC Approval Conditions (EPBC 2008/4146) and related EP sections

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
1) The person taking the action must submit, for the Minister's approval, a plan (or plans) for managing the offshore impacts of the action. The plan (or plans) must include measures for: a) Production drilling activities: a) Well locations; b) Drilling fluid types and disposal method; c) Drill cutting disposal method; d) Fuel and chemical handling and transfer procedures; e) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; and f) Cetacean sightings reporting. b) Offshore construction and installation, including: a) Design and construction that allows for the complete removal of all structures and components above the seafloor during decommissioning; b) Details of the anchor type and placements, methods for connection of mooring lines, installation of the risers and flowline paths; c) Measures to minimise seabed disturbance; d) Hydrotest fluid type, handling and disposal methods; e) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; f) Cetacean sightings reporting; and g) Measures for reporting environmental incidents. c) Operations, including: a) Offtake tanker vetting procedures; b) Produced formation water and naturally occurring radioactive materials monitoring and management;	Shell has prepared, submitted for assessment and implemented EPs for all stages of the Prelude FLNG development to date. This EP relates only to the start-up, operations and Crux tie-in phases of the action or as amended from time to time. 1a) Production drilling activities are beyond the scope of the petroleum activities considered in this EP. 1b) Offshore construction and installation activities are beyond the scope of the petroleum activities considered in this EP with the exception of the Crux tie-in activity as described in Section 6.4.7. 1c) i) Offtake tanker vetting procedures are provided in Section 10.4.3. ii) The impacts and risks from produced formation water and naturally occurring radioactive materials, along with monitoring and management measures, are assessed in Section 9.9, Section 9.12 and Section 10.4.1. iii) The impacts and risks from artificial lighting and noise, along with monitoring and management measures, are assessed in Section 9.4 and Section 9.5. iv) Procedures for supply vessels and aircraft that are consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 are provided in Section 9.5 and Section 9.7. v) Measures for reporting environmental incidents are provided in Section 10.5.2.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
c) Measures to reduce artificial lighting and noise associated with operation; d) Cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the *Environment Protection and Biodiversity Conservation Regulations 2000*; e) Cetacean sightings reporting; and f) Measures for the reporting of environmental incidents. The plan (or plans) must be submitted at least two months prior to the commencement of these activities. Individual offshore activities, as defined within these conditions, may not commence until the plan (or plans) for that specific activity have been approved. The approved plan (or plans) must be implemented.	This EP was originally submitted greater than two months prior to commencing Prelude FLNG operations.
4) The person taking the action must develop and submit to the Minister for approval, an Oil Spill Contingency Plan that demonstrates the response preparedness of the person taking the action for any hydrocarbon spills, including the capacity to respond to a spill and mitigate the environmental impacts. The Plan must include, but is not limited to: a) Oil spill trajectory modelling for potential spills from the action. This should include consideration of a well blow out or uncontrolled release. The modelling should be specific to the characteristics of the hydrocarbons contained in the Prelude gas field, the likely volumes released in a worst-case scenario spill, and the potential time over which the oil may be released in a worst-case scenario spill, including a scenario of eleven (11) weeks uncontained spill. b) A description of resources available for use in containing and minimising impacts in the event of a spill and arrangements for accessing these. c) A demonstrated capacity to respond to a spill at the site, including application of dispersants, if required and appropriate, and measures that can feasibly be applied within the first 12 hours of a spill occurring. d) Identification of sensitive areas that may be impacted by a potential spill, in particular Browse Island, specific response measures for these areas and prioritisation of these areas during a response. e) Training of staff in spill response measures and identifying roles and responsibilities of personnel during a spill response. f) Procedures for reporting oil spill incidents.	Shell has undertaken a detailed hydrocarbon spill risk assessment, developed an Oil Pollution Emergency Plan (OPEP) (HSE_PRE_013075) and an associated Operational and Scientific Monitoring Plan (OSMP) (which includes the APPEA OSMP Framework and supporting Operational and Scientific Monitoring Bridging and Implementation Plan) which combined with this EP, meet the requirements of condition 4 as per the following: a) Key outputs from oil spill trajectory modelling for potential spills are provided in Section 9.13. b) Spill resource availability and access requirements are addressed in the OPEP. c) Demonstrated capacity (including dispersant application) to respond to a spill is provided for in the OPEP. d) Environmental sensitivities (including Browse Island) located within the Zone of Potential Impact (ZPI) are described in Section 9.13. Specific response measures for Browse Island and the Spill Impact Mitigation Analysis (SIMA) process are provided in the OPEP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
The Oil Spill Contingency Plan must be submitted at least three months prior to the commencement of drilling activities. The person taking the action must not commence Prelude production drilling activities until the Oil Spill Contingency Plan is approved. The approved Oil Spill Contingency Plan must be implemented.	e) Training requirements for personnel undertaking oil spill response are provided in Section 10.3.3. Roles and responsibilities for spill response are contained within the OPEP. f) Requirements for reporting oil spill incidents are provided in Section 10.5.2 and the OPEP.
5) The person taking the action must develop and submit to the Minister for approval, and Operational and Scientific Monitoring Program that will be implemented in the event of an oil spill to determine the potential extent and ecosystem consequences of such a spill, including, but not limited to: a) Triggers for the initiation and termination of the Operational and Scientific Monitoring Program, including, but not limited to, spill volume, composition, extent, duration and detection of impacts; b) A description of the studies that will be undertaken to determine the operational response, potential extent of impacts, ecosystem consequences and potential environmental reparations required as a result of the oil spill. c) Inclusion of sufficient baseline information on the biota and the environment that may be impacted by a potential hydrocarbon spill, to enable an assessment of the impacts of such a spill. d) A strategy to implement the scientific monitoring plan, including timelines for delivery of results and mechanisms for the timely peer review of studies, and e) Provision for periodic review of the program. The Operational and Scientific Monitoring Program must be submitted at least three months prior to the commencement of drilling activities. The person taking the action must not commence Prelude production drilling activities until the Operational and Scientific Monitoring Program is approved. The approved Operational and Scientific Monitoring Program must be implemented.	As stated above, Shell has addopted an OSMP that may be implemented in the event of a hydrocarbon spill. The OSMP scales in response to the nature and scale of the spill and the environmental receptors at risk. The OSMP has discrete initiation and termination criteria for each of the components of the OSMP. The OSMP includes consideration of baseline data and provides for sampling of receptors identified at being at risk prior to being contacted by hydrocarbons in the event of a spill. The arrangements by which Shell maintains preparedness to implement operational and scientific monitoring are detailed in the OSMP, the OPEP and Section 10.7.
7) The person taking the action must submit a Decommissioning Plan to the Minister for approval one year prior to the decommissioning of the Prelude Floating Natural Gas Facility or any subsea wells, flowlines or associated infrastructure. The Decommissioning Plan must consider the	No decommissioning activities are planned as part of the petroleum activities considered in this EP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
complete removal of all structures and components above the sea floor. The approved Decommissioning Plan must be implemented.	
11) The person taking the action may choose to revise a management plan approved by the Minister under conditions 1, 4, 5 and 7 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the person taking the action makes this choice they must: i) Notify the Department in writing that the approved plan has been revised and provide the Department with an electronic copy of the revised plan; ii) Implement the revised plan from the date that the plan is submitted to the Department; and iii) For the life of this approval, maintain a record of the reasons the person taking the action considers that taking the action in accordance with the revised plan would not be likely to have a new or increased impact.	Shell may revise the EP, OPEP and OSMP without providing notification to the Minister or NOPSEMA if no significant new environmental risks/impacts or increases to identified environmental risks/impacts considered in these plans are identified. Triggers for submission of an EP revision to NOPSEMA are provided in Section 10.1.9.
11A) The person taking the action may revoke their choice under condition 11 at any time by notice to the Department. If the person taking the action revokes the choice to implement a revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.	Shell does not intend to revoke their choice in relation to the submission of plans detailed in condition 11. If Shell do elect to revoke their choice, they will implement the plan approved by the Minister.
11B) If the Minister gives a notice to the person taking the action that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then: i) Condition 11 does not apply, or ceases to apply, in relation to the revised plan; and ii) The person taking the action must implement the plan approved by the Minister. To avoid any doubt, this condition does not affect any operation of conditions 11 and 11A in the period before the day the notice is given. At the time of giving the notice the Minister may also notify that for a specified period of time that condition 11 does not apply for one or more specified plans required under the approval.	Shell accepts that any new or increased impact in a revision to a management plan specified in condition 11 will result in condition 11 not being applicable and Shell will implement the plan accepted by the Minister.
11C) Conditions 11, 11A and 11B are not intended to limit the operation of section 143A of the Act which allows the person taking the action to submit a revised management plan to the Minister for approval.	Not directly applicable to this EP.

Approval Conditions (EPBC 2008/4146)	Relevant EP Sections
14) A plan or program required by condition 1, 4 or 5 has been approved by the Minister and the measures (as specified in the relevant conditions) are included in an environment plan (or Environment Plans) that: a) Was submitted to NOPSEMA after 27 February 2014; or b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations.	Noted – Shell intends to meet the requirements of the consolidated conditions detailed in EPBC 2008/4146 by submitting the EP, OPEP and OSMP to NOPSEMA.
14A) Where a plan or program required by condition 1, 4 or 5 has been approved by the Minister and the measures (as specified in the relevant condition) are included in an environment plan (or Environment Plans) that: a) Was submitted to NOPSEMA after 27 February 2014; or b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations. the plan or program approved by the Minister no longer needs to be implemented provided the environment plan remains in force.	Shell has submitted the plans required by conditions 1, 4 and 5 to NOPSEMA as part of an EP submission for the activity.
14B) Where an environment plan, which includes measures specified in the conditions referred to in conditions 14 and 14A above, is in force under the OPGGS Environment Regulations that relates to the taking of the action, the person taking the action must comply with those measures as specified in that environment plan.	Shell intends to comply with the conditions in the EP submissions made to NOPSEMA.

3.1.2.2 Australian Marine Park Management Plans

The EPBC Act provides for the declaration of Australian Marine Parks (AMPs) based on the International Union for the Conservation of Nature (IUCN) principles and guidelines for categorising protected areas. Australia has established a network of AMPs throughout Commonwealth waters, which are managed under a series of region-based management plans. These plans detail the management objectives of the AMPs, the environmental values within each of the AMPs and the activities that area permissible within the zones of the AMPs. AMPs are part of the Commonwealth Marine Area, which is an MNES.

The planned petroleum activities considered within this EP will not credibly impact upon any AMPs, however an unplanned hydrocarbon spill from a worst-case loss of well containment was identified as potentially impacting upon several AMPs. These AMPs are described in Section 7.3.2 and managed under the Australian Marine Parks - North Marine Parks Network Management Plan 2018 (Director of National Parks 2018a) and Australian Marine Parks - North-west Marine Parks Network Management Plan 2018 (Director of National Parks 2018b).

The requirements of the management plans for AMPs are considered as part of Shell's determination of the acceptability of environmental impacts and risks. Refer to Section 9.3 to Section 9.14 for further information.

3.1.2.3 Recovery Plans and Conservation Advice

Species and communities listed as threatened under the EPBC Act are MNES and receive protection under Commonwealth law. The Threatened Species Scientific Committee may publish conservation advice for a threatened species, which provides information on threats and conservation management. Recovery plans relating to threatened species may also be published by the Commonwealth Department of the Environment and Energy. Recovery plans are intended to provide a framework to prevent further decline, and facilitate the recovery, of threatened species. Recovery plans may contain actions that warrant consideration during the assessment of environmental impacts and risks. Recovery plans may also identify habitat critical for the survival of a species; such habitat is protected under the EPBC Act.

Shell has identified a number of threatened species that may credibly be impacted, or are at risk of being impacted, by the petroleum activities considered in this EP. Details on these species, along with relevant information from recovery plans and conservation advice, are provided in Section 7.2.8.

3.1.3 Other Legislation

Other legislation applicable to the environmental management of the petroleum activities considered in this EP, along with a justification as to why they are relevant, are provided in Table 3-3.

Table 3-3: Summary of Relevant Legislation

Legislation	Summary	Relevance to the Project
Australian Heritage Council Act 2003	This Act identifies areas of heritage value, including those listed on the World Heritage List, National Heritage List and the Commonwealth Heritage List (all of which are MNES under the EPBC Act).	The EP will take into consideration any heritage values (see Section 7.3.1 for details).
Australian Maritime Safety Authority Act 1990	Provides that a function of AMSA is to combat pollution in the marine environment. AMSA is the control agency for vessel-based non-petroleum activity spills in commonwealth waters.	Vessel emergencies, including oil spills in Commonwealth waters.
Biodiversity Conservation Act 2016 (Western Australia) Biodiversity Conservation Regulations 2018	Requires WA conservation management agencies to take a lead role in oiled wildlife response in Western Australia. DBCA has the responsibility and statutory authority to treat, protect and destroy wildlife.	Oiled wildlife response will comply with this Act.
Biosecurity Act 2015	The Act and its supporting legislation are the primary legislative means for managing risk of pests and diseases entering Australian territory. The Act includes requirements for pre-arrival reporting, ballast water management plans and certificates.	The EP will comply with biosecurity requirements, specifically in relation to biofouling and ballast water requirements.
Emergency Management Act 2005 (Western Australia)	Requires the WA DoT (Hazard Management Agency) shall be the Control Agency for spills within or entering WA state waters. It is the legislative basis for the WA WestPlan – MOP.	Emergencies including oil spills which enter state waters.
Environment Protection (Sea Dumping) Act 1981	This Act protects is intended to prevent pollution of the sea by prohibiting the discharge of potentially harmful materials to the sea.	Chemical inventories onboard the Prelude FLNG facility may potentially breach this convention if unpermitted via this EP and deliberately discharged to the sea.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	This Act regulates the export, import and transport of hazardous waste to ensure that hazardous waste is managed appropriately so that human health and the	The project will comply with the export, import and transport requirements for hazardous waste.

Legislation	Summary	Relevance to the Project
	environment are protected from the harmful effects of the waste.	
National Environment Protection (National Pollutant Inventory) Measure 1998 (established under the *National Environment Protection Council Act 1994*)	This measure provides the framework for the development and establishment of the National Pollutant Inventory (NPI), which provides publicly available information on the types and amounts of 93 toxic substances being emitted into the Australian environment. These substances have been identified as important due to their possible effect on human health and the environment.	The project will comply with the NPI NEPM through the reporting of relevant NPI substances.
National Environment Protection Council Act 1994	This Act establishes the National Environment Protection Council (NEPC). The primary functions of the NEPC are to define National Environment Protection Measures (NEPMs) to ensure that Australians have equivalent protection from air, water, soil and noise pollution, and assess and report the implementation and effectiveness of NEPMs.	The project will comply with the requirements of the relevant NEPMs.
National Greenhouse and Energy Reporting Act 2007 National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015	The Act provides a single, national framework for the reporting and distribution of information related to greenhouse gas (GHG) emissions, GHG projects, energy production and energy consumption. Reporting obligations are imposed upon corporations that meet emissions/energy thresholds. The Act includes National Greenhouse and Energy Reporting (NGER) requirements and the Safeguard Mechanism requirements.	Shell reports as a corporate group under the Act which includes emissions from the Prelude FLNG. Prelude FLNG has committed to a baseline under the Safeguard Mechanism requirement.
Navigation Act 2012 Navigation Regulations 2013 Marine Order 21 (Safety and emergency arrangements) 2016	This Act relates to maritime safety and the prevention of pollution of the marine environment in Australian waters. It gives effect to several international conventions relating to maritime issues to which Australia is a signatory. The Act also has subordinate	The project, including vessels, will adhere to the Act and subsidiary legislation enabled by the Act, such as Marine Orders relating to the international conventions listed in Section 3.3**.**

Legislation	Summary	Relevance to the Project
Marine Order 27 (Safety of navigation and radio equipment) 2016 Marine order 28 (Operations standards and procedures) 2015 Marine Order 30 (Prevention of collisions) 2016 Marine order 60 (Floating offshore facilities) 2001 Marine Order 71 (Masters and deck officers) 2014	legislation contained in Regulations and Marine Orders.	
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and Regulations 1995	The Act protects the environment by reducing emissions of ozone depleting substances (ODSs) and synthetic greenhouse gases (SGGs). It controls the manufacture, import and export of ODSs and SGGs and products containing these gases.	The project will adhere to restrictions on import and use of ODSs/SGGs through implementing appropriate measures that control procuring of products which contain these gases.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994 Marine Order 91 (Marine pollution prevention — oil) 2014 Marine Order 93 (Marine pollution prevention — noxious liquid substances) 2014 Marine Order 94 (Marine pollution prevention — packaged harmful substances) 2014 Marine Order 95 (Marine pollution prevention — garbage) 2018 Marine Order 96 (Marine pollution prevention — sewage) 2018 Marine Order 97 (Marine pollution prevention — air pollution) 2013	The Act regulates discharges from ships to protect the sea from pollution. This includes regulation of discharges of oil or oily mixtures, noxious liquid substances, packaged harmful substances, sewage and garbage to the sea. The Act imposes a duty to report certain incidents involving prohibited discharges and to maintain record books and management plans. The Act and subsidiary Marine Orders enact the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL).	Vessels within the Operational Area are subject to this Act and will adhere to the requirements for discharges and waste management outlined in the relevant MARPOL and Marine Orders (as appropriate to vessel class).

Legislation	Summary	Relevance to the Project
Underwater Cultural Heritage Act 2018	An Act to protect Australia's underwater cultural heritage. The Act came into effect on 1 July 2019, replacing the *Historic Shipwrecks Act 1976*. This act protects Australia's shipwrecks, and broadens protection to sunken aircraft and other types of underwater cultural heritage.	Planned petroleum activities will not interfere with any underwater cultural heritage sites (see Section 7.3.1 for details).

3.2 Standards and Guidelines

3.2.1 Industry Good Practice Standards

In Australia, the petroleum exploration and production industry operates within an industry code of environmental practice developed by the Australian Petroleum Production and Exploration Association (APPEA) (APPEA 2008). This code provides guidelines for activities and has evolved from the collective knowledge and experience of the oil and gas industry both nationally and internationally. The code provides the Australian petroleum industry with guidance on management measures to protect the environment during exploration, production and decommissioning phases. Shell is a signatory to the APPEA guidelines and will align with their intent in the implementation of this EP.

The following Australian guidelines are also applicable to the project:

- GN1344 Environment Plan Content Requirements Guidance Note (NOPSEMA 2019a)
- GN1785 Petroleum activities and Australia marine parks (NOPSEMA 2018a)
- GN1488 Oil Pollution Risk Management (NOPSEMA 2018b)
- IP1349 Operational and Scientific Monitoring Programs (NOPSEMA 2016)
- IP1765 Acoustic impact evaluation and management (NOPSEMA 2018c)
- Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017)
- National Biofouling Management Guidance for the Petroleum Production and Exploration Industry 2009 (Department of Agriculture, Fisheries and Forestry 2009)
- Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA 2015)
- Advisory Note for Offshore Petroleum Industry Consultation with Respect of Oil Spill Contingency Plans (AMSA 2018), and the corresponding Marine Oil Pollution: Response and Consultation Arrangements (Department of Transport 2017).

The following international guidelines are also applicable to the project:

- Improving Social and Environmental Performance: Good Practice Guidance for the Oil and Gas Industry (IPIECA 2017)
- Environmental Management in Oil and Gas Production (United Nations Environment Program and Oil Industry International Exploration and Production Forum 1997).

3.2.2 International Standards and Guidelines

Shell refers to World Bank (WB)/International Finance Corporation (IFC) guidelines as the basis for many of its operation guidelines, as aligned with the Shell HSSE & SP Control Framework. The WB/IFC guidelines are the minimum environmental, social and health standards for WB funded projects, unless the standards of the host country are more stringent.

The WB/IFC guidelines of primary relevance to the project include:

- IFC Performance Standards on Environmental and Social Sustainability (IFC 2012)
- General Environmental, Health, and Safety (EHS) Guidelines (IFC 2007)
- EHS Guidelines for Offshore Oil and Gas Development (IFC 2015).

3.2.3 Shell Health, Security, Safety, Environment and Social Performance Management Framework

Shell maintains and implements a Health, Security, Safety, Environment and Social Performance Management Framework, which contains a range of standards and guidelines. It is the means by which Shell ensures that the industry good practice standards and international standards and guidelines detailed in Sections 3.2.1 and 3.2.2 are implemented. It forms the basis of the implementation strategy of this EP. Refer to Section 4.0 for further information.

3.3 International Agreements and Conventions

Australia is signatory to several international conventions and agreements that are relevant to the environmental management of the petroleum activities considered in this EP. These are typically implemented by Commonwealth legislation, much of which is detailed above in Section 3.1. Relevant international agreements and conventions, along with a justification of their relevance to the petroleum activities considered in this EP, are provided in Table 3-4.

Table 3-4: Summary of relevant international agreements and conventions

Agreement / Convention	Summary	Relevance to the Project
Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention)	This convention aims to conserve migratory fauna species throughout their ranges, particularly where their range crosses international jurisdictional boundaries. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under the Bonn Convention to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several species listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section 7.2.8.
The East Asian - Australasian Flyway Partnership 2006 (EAAFP)	Adopted in the list of the World Summit on Sustainable Development as a Type II initiative which is informal and voluntary, the Partnership was launched on 6 November 2006 and aims to protect migratory waterbirds, their habitat and the livelihoods of people dependent upon them. There are currently 37 Partners including 18 countries, 6 intergovernmental agencies, 12 international non-governmental organisations (NGOs) and 1 international private enterprise.	Several migratory birds species that utilise the East Asian - Australasian Flyway were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
The Agreement on the Conservation of Albatrosses and Petrels (ACAP)	ACAP through its 13 Parties strives to conserve albatrosses and petrels by coordinating international activities to mitigate threats to their populations.	Several albatross and petrel species were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA)	This agreement aims to conserve migratory bird species that travel between Japan and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under JAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Section Refer to Section 7.2.8.
Agreement between the Government of Australia and the Government of the People's Republic of China for the	This agreement aims to conserve migratory bird species that travel between China and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section 7.2.8.

Agreement / Convention	Summary	Relevance to the Project
Protection of Migratory Birds and their Environment 1986 (CAMBA)	makes provision for species listed under CAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	
Agreement between the Government of Australia and the Government of the Republic for Korea for the Protection of Migratory Birds and their Environment 2007 (ROKAMBA)	This agreement aims to conserve migratory bird species that travel between the Republic of Korea and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under ROKAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this EP. Refer to Section Refer to Section 7.2.8.
International Convention on Wetlands of International Importance 1975 (Ramsar)	This convention aims to conserve and promote the sustainable human use of wetlands. Many wetlands have been identified as important habitat for migratory bird species, and Ramsar wetlands are of importance in conserving many species of migratory shorebirds and waders. Ramsar wetlands are protected under the EPBC Act and are MNES.	The Ashmore Reef Ramsar wetland was identified as potentially being impacted in the event of an unplanned release of large volumes of hydrocarbons (e.g. loss of well control). Refer to Section 7.2.5.
Memorandum of Understanding between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Exclusive Fishing Zone and Continental Shelf 1974	This memorandum recognizes the long history of traditional Indonesian fishermen exploiting biological resources within Timor Sea waters within Australia's exclusive economic zone. The memorandum provides for an area (commonly referred to at the MoU box) within which traditional Indonesian fishing is permitted. The area includes several offshore reefs, including Ashmore Reef, Cartier Island, Scott Reef and Seringapatam Reef.	The Prelude FLNG Project is situated within the MoU box. Refer to Section 7.3.3.
London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention)	This convention is an agreement to control pollution of the sea by intentional disposal at sea of potentially harmful materials. It is implemented under Commonwealth law by the *Environment Protection (Sea Dumping) Act 1981*.	Chemical inventories onboard the Prelude FLNG facility may potentially breach this convention if unpermitted via this EP and deliberately discharged to the sea.

Agreement / Convention	Summary	Relevance to the Project
Minamata Convention on Mercury 2017	This convention is an agreement to protect human and environmental health from the effects of releases of mercury and mercury-containing compounds to the environment. The convention is not yet ratified by Australia, and hence is not currently implemented in Commonwealth law. Australia has signed the convention and is currently undertaking an assessment process prior to ratification.	Petroleum production by the Prelude FLNG may result in mercury compounds being produced from petroleum reservoirs as a by-product. Mercury may pose a risk to the environment if not managed appropriately.
International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL)	This convention is an agreement to minimise the pollution of the marine environment by ships. The convention provides a standardised approach to the environmental management of international and domestic shipping. The convention is implemented in Commonwealth law by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and a series of Marine Orders made under this Act.	All marine support vessels are required to comply with MARPOL.
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW)	This convention provides a standardised approach to the qualifications and competencies of masters, officers and watch personnel. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels and crew are required to comply with STCW.
International Convention for the Safety of Life at Sea 1974 (SOLAS)	This convention provides internationally agreed minimum standards for the construction, equipment and operation of vessels. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with SOLAS.
International Regulations for Preventing Collisions at Sea 1972 (COLREGS)	These regulations provide internationally agreed rules for the navigation of vessels, which are intended to reduce the likelihood of vessel collisions. COLREGS are implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with COLREGS.

4.0 Shell Environmental Management Framework

4.1 Shell Health, Security, Safety, Environment and Social Performance Management Framework

The Shell Group operates under a common set of business principles, supported by policies, standards and business controls which are implemented throughout the organisation structure. In support of the business principles, there is a Group Health, Security, Safety, Environment and Social Performance Policy which requires every Shell Company to manage HSSE and SP in a systematic manner.

The HSSE and SP Control Framework is a corporate management framework which applies to every Shell Group company, contractor and joint venture under Shell's operational control.

4.2 HSSE & SP Policy

The Shell Commitment and Policy on HSSE & SP applies across the Shell Group and is designed to protect people and the environment. The policy, endorsed and adopted by Shell, is presented in Figure 4-1. The policy illustrates the commitment made by the senior management and all staff of Shell to achieve not only compliance with environmental standards set by the Australian Government and the Company, but also to seek continual improvements in performance.

Key features of the policy are:

- systematic approach to HSSE and SP management designed to ensure compliance with the law and to achieve continuous performance improvement
- targets for improvement and measurement, appraisal and performance reporting
- requirement for contractors to manage HSSE and SP in line with this policy
- effective engagement with neighbours and impacted communities.

SHELL COMMITMENT AND POLICY ON HEALTH, SECURITY, SAFETY, THE ENVIRONMENT AND SOCIAL PERFORMANCE

COMMITMENT

In Shell we are all committed to:

- Pursue the goal of no harm to people;
- Protect the environment;
- Use material and energy efficiently to provide our products and services;
- Respect our neighbours and contribute to the societies in which we operate;
- Develop energy resources, products and services consistent with these aims;
- Publicly report on our performance;
- Play a leading role in promoting best practice in our industries;
- Manage HSSE & SP matters as any other critical business activity; and
- Promote a culture in which all Shell employees share this commitment.

In this way we aim to have an HSSE & SP performance we can be proud of, to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development.

POLICY

Every Shell Company:

- Has a systematic approach to HSSE & SP management designed to ensure compliance with the law and to achieve continuous performance improvement;
- Sets targets for improvement and measures, appraises and reports performance;
- Requires contractors to manage HSSE & SP in line with this policy;
- Requires joint ventures under its operational control to apply this policy, and uses its influence to promote it in its other ventures;
- Engages effectively with neighbours and impacted communities; and
- Includes HSSE & SP performance in the appraisal of staff and rewards accordingly.

Ben van Beurden
Chief Executive Officer

Zoe Yujnovich
EVP Australia and New Zealand

Originally published in March 1997 and updated by the Executive Committee December 2009.

General Disclaimer: The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this Policy the expression "Shell" is sometimes used for convenience where references are made to companies within the Shell group or to the group in general. Likewise, the words "we", "us" and "our" are also used to refer to Shell companies in general or those who work for them. These expressions are also used where no useful purpose is served by identifying specific companies.

Figure 4-1: Shell Australia's HSSE & SP Policy

4.3 HSSE & SP Control Framework

All Shell's operations are conducted in accordance with Shell's HSSE & SP Control Framework, a comprehensive corporate management framework. This Framework defines a set of mandatory requirements that define minimum HSSE & SP principles and expectations, which are documented in a set of manuals. Figure 4-2 outlines the various control framework manuals applicable to Prelude FLNG.

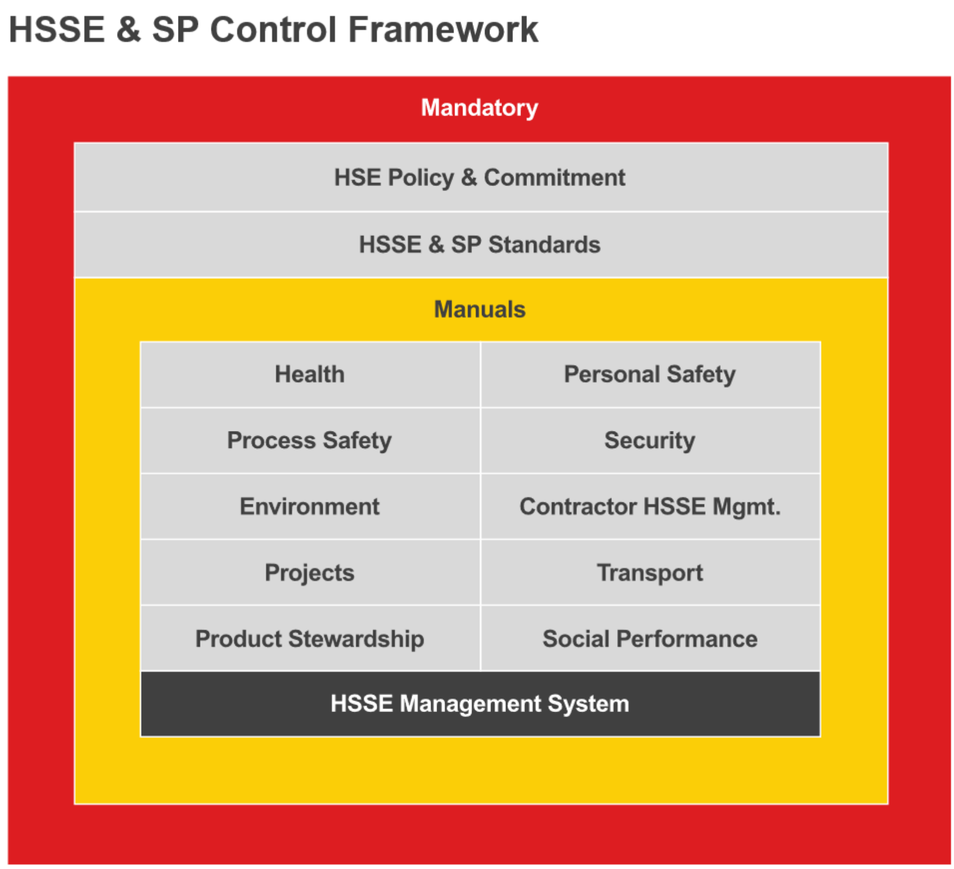


Figure 4-2: Shell HSSE & SP Control Framework

4.4 HSSE & SP Management System (MS)

The Shell HSSE &SP-MS provides a structured and documented system for the effective management of impacts and risks and demonstrates how the requirements of the Shell Group HSSE & SP Control Framework are implemented throughout Shell. The Shell]HSSE & SP-MS Manual consists of the following elements:

- Leadership and Commitment
- Policy and Objectives
- Organisation, Responsibility and Resources, Standard and Documents
- Risk Management
- Planning and Procedures
- Implementation, Monitoring and Reporting
- Assurance, and
- Management Review.

The HSSE & SP-MS is subject to a continuous improvement ‘plan, do, check, review’ loop, with the eight elements as listed above. There are numerous, specific ongoing (typically annual) assurance activities against each of the eight elements in the HSSE & SP-MS Manuals, to ensure that the system is being implemented, is effective and to identify areas for improvement.

Environmental management for Prelude is through the implementation of the Shell HSSE & SP-MS, supplemented by facility/asset specific HSSE systems/procedures (e.g. Shell Permit to Work system and associated procedures such as Confined Space Entry, Isolations, etc. as appropriately developed at the stage of project implementation).

Shell implements specific pre- and post-contract award processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks and deliver effective management of HSSE & SP risks for contracted activities. Contractor HSSE & SP Management is governed by the Shell HSSE & SP Control Framework.

As a minimum, all relevant field active contractors' HSSE & SP-MS will be assessed to ensure they meet materially equivalent outcomes to Shell's HSSE & SP-MS.

5.0 Stakeholder Consultation

As titleholder, Shell has consulted with relevant persons in accordance with the NOPSEMA Decision-making guideline – Criterion-10A(g) Consultation Requirements (N-04750-GL1721 Rev 6 2019a) and NOPSEMA's Bulletin #2 (2019c) under the OPGGS (E) Regulations 2009 for this Prelude FLNG Environment Plan (EP) (Document number: 2000-010-G000-GE00-G00000-HE-5880-00002).

Shell has ensured all Relevant Persons have been provided with sufficient information and had the opportunity to raise any objections or claims.

Shell has addressed objections and claims raised in relation to this EP and can demonstrate that the risk or impact in question has been reduced to ALARP and to an acceptable level.

5.1 Background

Consultation and stakeholder engagement for Prelude began when the gas field was first discovered in early 2007 and has continued since the Final Investment Decision (FID) was taken in May 2011. This included a thorough consultation process on the environmental impacts for the Prelude FLNG Project Environmental Impact Statement. The project received environmental approval under the Environment Protection and Biodiversity Act 1999 on the 12th November 2010 (EPBC 2008/4146). Extensive consultation was subsequently carried out to support the acceptance of the Prelude Drilling and Completions Environment Plan (2012), the Prelude Subsea Installation Environment Plan (2014) and the Prelude Installation and Operations Environment Plan (2016).

This consultation overview outlines the approach for the submission of this revised Prelude EP now that Prelude has moved into production.

5.2 Shell General Business Principles and Stakeholder Engagement

Stakeholder engagement and consultation is an integral part of Shell's social performance, impact assessment and project development process, helping to both inform business decisions and identify issues that require action. Shell has internal policies and processes which outline the requirements of stakeholder engagement. These are underpinned by Shell's General Business Principles (refer to Section 3.2

Standards and Guidelines), which govern how the Shell companies that make up the Shell Group conduct their affairs.

Key principles for stakeholder engagement:

- Local communities – Shell aims to be a good neighbour by continuously improving the ways in which we contribute directly or indirectly to the general wellbeing of the communities within which we work. We manage the social impacts of our business activities carefully and work with others to enhance the benefits to local communities, and to mitigate any negative impacts from our activities. In addition, Shell companies take a constructive interest in societal matters, directly or indirectly related to our business.
- Communication and engagement – Shell recognises that regular dialogue and engagement with our stakeholders is essential. In our interactions with local communities, we seek to listen and respond to them honestly and responsibly. Part of this commitment is ensuring those people and organisations that are impacted by our activities are engaged, and that their concerns are heard and responded to.

5.2.1 Stakeholder Engagement Process

In supporting Shell's adherence to the Shell general Business Principles is a comprehensive stakeholder strategy which ensures that:

- the external context is monitored and understood
- stakeholder needs, interests, concerns and expectations are understood, shared and outcomes defined
- there is a clear and direct link between impacts and risks/opportunities
- stakeholder engagement protocols established and consistent
- explicit inclusion of external perspectives in business decisions.

5.2.2 The Team

Shell Australia has a Perth based External and Government Relations (EGR) team, which includes Social Performance, who facilitate stakeholder and community engagement in Australia on behalf of the business with support teams in Canberra, Melbourne and Queensland.

The EGR team manages the interface for the business with external stakeholders such as, communities, NGOs, Government(s) and the media. Working as an integrated team allows a 'whole of Shell view' to be provided in stakeholder engagements and ensure stakeholders receive consistent and coordinated information. This is important where, for example, exploration activities and Crux (Prelude's primary backfill), have similar stakeholders to Prelude and therefore require an aligned approach. We call this grouping East Browse.

An EP specific meeting is held monthly between the relevant HSSE and External Relations leads which is driven by the EP commitments register.

5.2.3 Prelude Stakeholder Engagement Plan

The Stakeholder Engagement Plan is an overarching East Browse Engagement Plan. This includes a stakeholder matrix, an engagement strategy and a feedback mechanism.

Shell's approach to stakeholder engagement for Prelude, as is the case for all of Shell's assets, has always been "no surprises" which has driven proactive engagements with a range of stakeholders from a very early stage. Shell has developed long term working relationships with those who may be impacted by Prelude or who may have an interest in it.

5.2.4 EP Consultation Strategy

The East Browse Stakeholder Engagement Plan was used to develop a fit for purpose EP consultation strategy as illustrated in Figure 5-1.

Subject-matter experts were engaged as required throughout the process, to inform the development of the plan and to ensure the EGR Team had sound understanding of the Prelude environmental risks and mitigations.

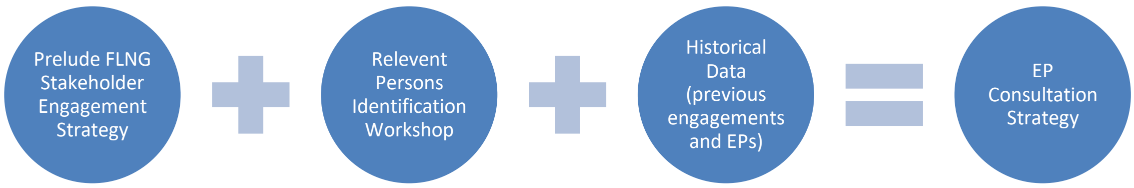


Figure 5-1: Development of Consultation Strategy

Relevant Persons

Shell has an internal process to identify, prioritise and understand stakeholders. The process includes the following steps:

1. Identify stakeholders against specific business objectives.
2. Prioritise stakeholders based on stakeholder views/concerns.
3. Analyse value drivers and views on our activities.
4. Define desired shared outcomes.
5. Early engagements with stakeholders to understand views of impacts, risks and opportunities.

This process was used to develop the Prelude FLNG Stakeholder Matrix and formed the foundation for a Relevant Persons Identification Workshop.

The workshop was attended by External and Government Relations representatives as well as Safety and Environment subject matter experts. During the workshop, each potential stakeholder was assessed based on how Prelude activities could impact their functions, interests or activity.

The workshop was informed by:

- historic information gathered as part of the initial Prelude EP submission and Shell Prelude stakeholder engagement process
- desktop research to identify the specific functions, interests and activities of each Relevant Person.

Once stakeholders were identified, Shell determined the most appropriate consultation approach and associated information to communicate based on the:

- functions, interests and activities of the person
- prior feedback and information from Relevant Persons on their perspectives and how they prefer to be engaged gathered as part of the Prelude stakeholder engagement process
- information gathered during prior engagement activities and/or ongoing communication with stakeholders.

The result was a list of all Relevant Persons who require formal consultation and their information requirements are shown in Table 5-3. Upon acceptance of this EP, Shell will uphold its commitments to ensuring Relevant Persons continue to be consulted throughout the five-year duration of this plan.

Consultation is tailored to the specific functions, interests or activities of the Relevant Persons. The planned frequency of these consultations for each Relevant Person can be found in Table 5-3. The frequencies and requirements were identified and discussed in the Relevant Persons Identification Workshop and updated as feedback was gathered as part of the consultation process.

The assessment is dynamic and could change, for example changes to scope, in which case the Prelude FLNG Stakeholder Engagement Plan would be updated. Progress of planned consultation is tracked and recorded in the Prelude FLNG Stakeholder Engagement Plan, and it is subject to a half yearly review.

Relevant Persons themselves can and have identified their preferred ongoing engagements for Prelude. In such cases, that suggestion is considered and if appropriate, implemented.

Shell's internal 'management of change' process will also ensure that any material changes to the activity scope will trigger engagement with those who may be impacted.

Relevant Persons will be reviewed as part of the standing agenda for the Prelude EP Monthly Meeting.

EP Guidance on Consultation

Stakeholder consultation for this activity has also been guided by various stakeholder organisation expectations for consultation on planned activities. The guidance consulted included but is not limited to those summarised in Table 5-1.

Table 5-1: Guidance for EP Stakeholder Consultation

Organisation	Guidance
NOPSEMA	• Consultation with Commonwealth agencies with responsibilities in the marine area (N-06800-GL1887 2019). • NOPSEMA Decision-making guideline – Criterion-10A(g) Consultation Requirements (N-04750-GL1721 rev 6 Nov 2019a) • Clarifying statutory requirements and good practice (NOPSEMA Bulletin #2 2019c)
AFMA	• Petroleum industry consultation with the commercial fishing industry

Commonwealth Department of Agriculture	• Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006 • Offshore Installations Biosecurity Guide 2019
WA Department of Primary Industries and Regional Development	• Guidance statement for oil and gas industry consultation with the Department of Fisheries 2013
WA Department of Transport	• Offshore Petroleum Industry Guidance Note September 2018

Reasonable Period

Shell has determined that a minimum of 30 days is reasonable period for formal consultation. This is a common duration specified for matters that are open to public comment and Shell's historic engagements supports that it is sufficient time to allow for a Relevant Person to assess the information provided by Shell in a letter containing all the risks as outlined in the EP and respond detailing any claims or objections.

The 30-day period acts as a minimum period in Shell's consultation planning processes, and Relevant Persons are explicitly asked to respond within that time. However, Shell acts on a case-by-case basis depending on the response received from Relevant Persons and will allow for requests to extend this period if requested. Shell will also follow up within that 30-day period if no response is received, where contact details are available.

As part of the review, it was identified that a reasonable period needed to be defined for ongoing consultation. Table 5-2 outlines Shell's approach.

Table 5-2: Reasonable Period for Ongoing Consultation

Type of Consultation	Timing
New, formal consultation The 30-day period acts as a minimum period in the consultation planning process for new information distributed to Relevant Persons.	30 days
Ongoing consultation The 14-day period acts as a minimum period to respond to claims or objections received once in the ongoing consultation phase. This will be managed on a case by case basis so that timeframes will take into account other factors (such as how much correspondence there has been with the Relevant Person, the merits of the claim or objection and/or the complexity of the claim or objection).	14 days

Sufficient Information

When carrying out consultation with Relevant Persons, Shell considers the potential impacts of Prelude activities on the particular functions, interests and activities of each Relevant Person to ensure that sufficient and appropriate information is provided. In summary, EP submission consultation involved the following:

<u>Letter and accompanying factsheet</u>

Shell provided Relevant Persons with a letter and accompanying information sheet outlining all the risks and mitigations extracted directly from the EP. This approach ensured that recipients had access to the impacts and risks outlined in the EP and the associated mitigations; and could make their own assessment on the impact of the activity. Therefore, removing potential for Shell to make any assumptions about what Relevant Persons would be interested or concerned about.

The factsheet also contained contact details, location specifics, details of the activity and the response period of 30 days (Appendix A: Detailed Facility Description), a link to the Prelude microsite and a link to the full draft Environment Plan, for those seeking more detailed information.

The letter and/or cover email was tailored to meet the needs of different Relevant Persons as determined by the Relevant Persons Identification workshop. For example, for Commercial Fishers who can only be contacted by mail.

Shell believes that this letter and factsheet, access to the full draft EP and the follow up process provided Relevant Persons with sufficient information to be able to consider the impacts on their functions, interests and activities.

Face-to-Face Meetings

In most cases, engagement for the EP did not require a face-to-face meeting and the majority of Relevant Persons did not wish to meet with Shell. However, in some cases where a Relevant Person showed considerable interest in the EP activities, face-to-face meetings were arranged to engage and share information. This also allowed access to and engagement with Shell subject-matter experts.

Prelude Website

Shell prepared a website outlining the content of the EP in digestible format for the general public. This website forms the basis for consultation, allowing stakeholders to select the information which interests them most. Once the EP is published on NOPSEMA's website, the Prelude website will provide a link to the EP submission for those that want more detailed information.

5.2.5 Assessment of merits of claims and objections

Shell has a claims process which guides our actions in response to claims and objections received from stakeholders related to Prelude. This process is included in Appendix A: Detailed Facility Description.

Claims received are processed through Shell's global system – Insight Browser. Identified Claims or Objections are tracked within this system. Failure to close out complaints in the system results in escalation to senior management and risks a breach of Shell's social performance standards.

Shell has adhered to NOPSEMA's guidance (N-04750-GL1721 Rev 6 2019a) in relation to the definitions of claims and objections, where an '*objection or claim*' is taken to mean:

- *To express opposition, protect, concern or complaint about the proposed activities; a request or demand that certain action be taken by the titleholder to address adverse impacts; and*
- *An assertion that there will be an adverse impact; or allegation to cast doubt about the manner in which the activities will be managed."*

5.2.6 Summary of Consultation

A summary of consultation activities undertaken, and the Relevant Persons consulted during the development of this EP are presented in Table 5-3 and Table 5-4. An assessment of merit was undertaken and is presented in Table 5-5.

Table 5-3: Assessment of Relevant Persons for the Activity

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
WA State and Commonwealth				
RP01	Australian Border Force	Yes	Maintains the integrity of Australia's international borders including customs and immigration.	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP02	Australian Hydrographic Service (Department of Defence)	Yes	The RAN Australian Hydrographic Service is the Commonwealth Government agency responsible for the publication and distribution of nautical charts and other information required for the safety of ships navigating in Australian waters. Issue notice to mariners and update nautical charts.	
RP03	Department of Agriculture	Yes	Biosecurity regulator and responsible for Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974.	
RP04	Department of the Environment and Energy	Yes	Administers the EPBC Act. Main functions are associated with providing oiled wildlife advice in commonwealth waters during an Oil spill.	
RP05	Department of Foreign Affairs and Trade (DFAT)	Yes	International relations with governments and other organisations. Specifically, DFAT will have functions relating to oil spills in international waters or foreign countries jurisdictions.	
RP06	Parks Australia	Yes	Parks Australia looks after Australia's natural treasures – including Kakadu, Uluru and our beautiful oceans. They are responsible for six national parks, 58 marine parks and the Australian National Botanic Gardens.	
RP07	Australian Marine Safety Authority (AMSA) including AMSA RCC.	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth Waters.	

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP08	Department of Water & Environmental Regulation	Yes	Responsible for implementing Commonwealth policies and programs to support the agriculture, fisheries, food and forestry industries.	
RP09	Department of Mines, Industry Regulation & Safety	Yes	Required to be consulted under the Regulations.	
RP10	Department of Primary Industry and Resources - Fisheries Division	Yes	Responsible for managing State fisheries.	
RP11	Department of Primary Industries and Regional Development NT	Yes	Responsible for managing Territory fisheries.	
RP12	WA Department of Biodiversity, Conservation & Attractions	Yes	Responsible for managing WA's parks, forests and reserves. Planned activities do not impact DBCA's functions, interests or activities.	
RP13	WA Department of Transport (DOT)	Yes	Legislated responsibility for oil pollution response in State Waters.	
RP75	Director of National Parks	Yes	The Director of National Parks is the statutory authority responsible for administration, management and control of Commonwealth marine reserves	
Commonwealth Fisheries				
RP14	Australian Fishery Management Authority (AFMA)	Yes	The Australian Fisheries Management Authority (AFMA) is the Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources, in particular, Section 7 of the Fisheries Administration Act 1991.	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP15 – RP22	North West Slope Trawl Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Bottom trawl.	

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP23	Southern Bluefin Tuna Fishery	Yes	The Southern Bluefin Tuna Fishery covers the entire sea area around Australia, out to 200 nm from the coast. Pelagic long line and purse seine fishing gear is used.	
RP24	Western Tuna & Billfish Fishery	Yes	Activities exist in or in close proximity to Prelude. Near surface longline and minor line gear used.	
Recreational Fisheries				
RP25	RecfishWest	No	Shell contacted RecFishWest and they have confirmed that no fishing is undertaken as far offshore as Prelude, and therefore they are not relevant.	• Not required
WA State Fisheries				
RP30 – RP56	Mackeral Managed Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Near-surface trawling activities near coastal areas primarily.	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP57 – RP59	North Coast Shark Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Primarily use demersal gillnets and longlines.	
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders	Yes	The only known active fishery that overlaps the operational area - primarily trap based fishery.	
RP68	Pearl Producers Association (PPA)	Yes	Peak industry representative body for the Pinctada maxima pearling industry licensees in Western Australia. Activities exist in or in close proximity to Prelude. Bottom drifting divers from Lacepede Islands south to Exmouth.	
RP69 – RP71	West Coast Deep Sea Fishery License Holders	Yes	Activities exist in or in close proximity to Prelude. Baited pots >150m water depth, mostly between 500 – 800 m.	

Stakeholder ID	Stakeholder	Relevant to activity	Relevance (Functions, Interests or Activities)	Frequency of Ongoing Consultation
RP72	Western Australian Fishing Industry Council (WAFIC)	Yes	Represents the interests of commercial fishers with licences in the WA State Managed Fishery.	
Industry				
RP73	INPEX	Yes	Adjacent titleholder; operator of WA-532-P and AC/P36	• As required through EP change assessments; or • When major non-standard activities arise which may directly affect the functions, interests or activities of the relevant person.
RP74	Finder No 13 Pty Ltd	Yes	Adjacent titleholder; operator of AC/P55	

Table 5-4: Stakeholder Consultation Activities During Development of EP

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
WA State and Commonwealth				
RP01	Australian Border Force	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		09 December 2019	Phone call	Followed up with a phone call.
		09 December 2019	Email	Email received closing out consultation.
RP02	Australian Hydrographic Service (Department of Defence)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		19 November 2019	Email	Email received closing out consultation.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP03	Department of Agriculture	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		10 December 2019	Email	Followed up with an email.
		11 December 2019	Email	Email response sent to Dept of Agriculture
		11 December 2019	Email	Email response received from Dept of Agriculture - they are reviewing the documentation at the moment and will provide a departmental coordinated response.
		12 December 2019	Email	Email to Department of Agriculture on MOU Box (74).
		18 December 2019	Conference call	Conference call arranged to discuss feedback and to walkthrough materials sent and clarify any questions from the Department.
		20 December 2019	Email	Email received from the Department confirming the biosecurity controls in the EP is consistent with their expectations keeping in mind that there will be new policy coming out on which Shell will be consulted
RP04	Department of the Environment and Energy	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		19 December 2019	Phone call	Follow up phone call.
		19 December 2019	Email	Follow up email.
		3 February 2020	Email	Follow-up email. Email response received from the Department saying as NOPSEMA is the regulating agency for this matter, the Department of Environment has no feedback on the plan.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP05	Department of Foreign Affairs and Trade (DFAT)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		18 December 2019	Phone call	Follow up phone call.
		18 December 2019	Email	Follow up email sent.
RP06	Parks Australia	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		25 November 2019	Email	Email received with request for further information.
		02 December 2019	Email	Map provided with coordinates and location relative to marine parks as requested.
RP07	Australian Marine Safety Authority (AMSA) including AMSA RCC.	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		3 February 2020	Email	Follow up email
RP14	Australian Fishery Management Authority (AFMA)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		17 December 2019	Email	Follow up email.
RP08	Department of Water & Environmental Regulation	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		19 December 2019	Phone call	Follow up call provided. Requested to send through material again to generic mailbox.
		20 December 2019	Email	Info resent to requested inbox.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP09	Department of Mines, Industry Regulation & Safety	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		16 December 2019	Email	Email received closing out consultation.
RP10	Department of Primary Industry and Resources - Fisheries Division	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		06 December 2019	Phone call	Phone call to discuss query regarding fish cube data and to test Shell's analysis.
		06 December 2019	Email	Email to DPIRD regarding clarification of fish cube data.
		18 December 2019	Phone call	Follow up phone call, information has been received and will be reviewed in early 2020.
		19 December 2019	Email	Email from DPIRD confirming fish cube data information.
		9 January 2020	Phone call	Follow up call, left voice message.
		14 January 2020	Phone call	Follow up call, DPIRD confirmed response will be received by end of the week.
		17 January 2020	Email	Email received from DPIRD with feedback and comments.
		31 January 2020	Email	Email response to DPIRD's comments.
RP11	Department of Primary Industries and Regional Development NT	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		18 December 2019	Phone call	Attempted follow up phone call to two contacts at the department with no response.
		18 December 2019	Email	Follow up email sent.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP12	WA Department of Biodiversity, Conservation & Attractions	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		18 December 2019	Email	Follow up email sent.
		18 December 2019	Email	Email received - automatic out of office reply.
		19 December 2019	Email	Email received closing out consultation.
		20 December 2019	Email	Email to close out consultation process.
RP13	WA Department of Transport (DOT)	01 October 2019	Email	Sent Draft OPEP provided for comment with supporting DOT industry guidance note information.
		07 November 2019	Email	Received from DoT with clarifications and comments on the draft OPEP
		19 November 2019	Email	Sent Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		27 November 2019	Email	Sent response to DOT comments/clarifications on the draft OPEP provided
		19 December 2019	Email	Received asking 2 clarifications
		20 December 2019	Email	Sent response to DOT comments/clarifications.
		07 January 2020	Email	Received from DOT asking question about spill modelling result sent.
		09 January 2020	Email	Sent response to DOT answering the question regarding spill modelling.
		21 January 2020	Email	Received from DOT stating no more questions on the content provided.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP75	Director of National Parks	19 December 2019	Email	Sent information on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan, including marine parks map.
		19 December 2019	Email	Received confirmation that planned activities do not overlap any Australian Marine Parks and no authorisation requirements from the DNP are required. Noted emergency response notification process to DNP if there are emergency oil/gas pollution incidents which occur within a marine park or are likely to impact on a marine park.
		31 January 2020	Email	Email to confirm consultation process closed.
Commonwealth Fisheries				
RP15 – RP22	North West Slope Trawl Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
RP23	Southern Bluefin Tuna Fishery	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
RP24	Western Tuna & Billfish Fishery	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
WA State Fisheries				
RP26 – RP56	Mackerel Managed Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
RP57 – RP59	North Coast Shark Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		09 December 2019	Email	Bespoke information on the risks and impacts to the Northern Demersal Scalefish Fishery provided.
		09 December 2019	Email	Email received closing out consultation.
RP68	Pearl Producers Association (PPA)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		11 December 2019	Phone call	Follow up phone call – unavailable.
RP69 – RP71	West Coast Deep Sea Fishery License Holders	19 November 2019	Mailed letter	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
RP72	Western Australian Fishing Industry Council (WAFIC)	19 November 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
		19 November 2019	Email	Email received from WAFIC requesting more bespoke information
		21 November 2019	Email	Email sent to WAFIC with more specific links to relevant information
		21 November 2019	Email	Email received from WAFIC
		25 November 2019	Email	Response sent to WAFIC with clarification on Prelude resubmission and map of Operational Area
		26 November 2019	Email	Email received from WAFIC
		06 December 2019	Email	Response sent to WAFIC

Stakeholder ID	Stakeholder	Date	Method	Consultation Activities
		19 December 2019	Email	Email received from WAFIC closing out consultation.
Industry				
RP73	INPEX	13 December 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.
RP74	Finder No 13 Pty Ltd	13 December 2019	Email	Info provided on proposed activity with information sheet, link to Prelude Environment Plan microsite and full draft Environment Plan.

Table 5-5: Stakeholder Claims and Objections – Assessment of Merit

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		WA State and Commonwealth			
RP01	Australian Border Force		Email received to say the ATT Delegate has not advised of any comments.	No claim or objection received.	Not applicable
RP02	Australian Hydrographic Service (Department of Defence)		Email received to say that the Australian Hydrographic Office have everything they need.	No claim or objection received.	Not applicable
RP03	Department of Agriculture	20 December 2019	Email received from the Department of Agriculture confirming the biosecurity controls in the EP is consistent with their expectations keeping in mind that there will be new policy coming out on which Shell will be consulted.	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP04	Department of the Environment and Energy	19 November 2019 19 December 2019 3 February 2020	Response received 3 February 2020 advising that as NOPSEMA is the regulating agency for this matter, the Department has no feedback on the plan.	No claim or objection received.	Not applicable
RP05	Department of Foreign Affairs and Trade (DFAT)	18 December 2019	Email received to confirm that DFAT cannot provide advice on the environmental approval processes as this matter does not fall within the remit of DFAT's policy responsibilities. Follow up phone call with DFAT Deputy Director (WA office), who confirmed that DFAT does not take a position on this type of consultation, so this closes out the consultation process with DFAT and no further action is required.	No claim or objection received.	Not applicable
RP06	Parks Australia		Guidance material developed by NOPSEMA in consultation with the Director of National Parks (DNP) requires that titleholders provide a description of the operational area including a map showing location of the activity relative to marine park boundaries. Relevant shapefiles for mapping are available at: https://parksaustralia.gov.au/marine/maps/ Stakeholder requested a map showing the distance to the mainland with coordinates showing Prelude location relative to marine parks.	No claim or objection received.	Not applicable
RP07	Australian Marine Safety Authority (AMSA) including AMSA RCC.	19 November 2019 3 February 2020	No response received	No claim or objection received.	Not applicable
RP14	Australian Fishery Management Authority (AFMA)		No response received	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP08	Department of Water & Environmental Regulation		No response received		Not applicable
RP09	Department of Mines, Industry Regulation & Safety		Email received to say that no further information is required at this stage.	No claim or objection received.	Not applicable
RP10	Department of Primary Industry and Resources - Fisheries Division	06 December 2019 18 December 2019 19 December 2019	Email to DPIRD regarding Fish Cube data clarification. Phone call to DPIRD. DPIRD to confirm fish cube data information in a follow up email and will respond formally with any specific EP comments in early 2020. DPIRD provided Shell with some clarification on Fish Cube data." Less than three vessels" does not constitute no fishing activity. Fish cube data differentiates between "less than 3 vessels" and "no fishing activity" for each block." DPIRD noted Shell committed (to WAFIC) to develop more bespoke material for the Northern Demersal Scalefish Fishery (NDSF) and set out specific information regarding impacts on fishing and fisheries activities related to Prelude activities. DPIRD had some additional minor comments on the draft prelude EP:	Suggest "Administrative and Procedural controls" for supporting vessels which aligns with proposed "NOPSEMA Offshore Support Vessel Reference Case" process. IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP. Suggest supporting vessels encouraged to have vessel specific (as per IMO guidance) Biofouling Management	Shell understands this reference case has not been finalised with NOPSEMA yet. However, Shell will consider this reference case once finalised. Supporting vessels attending site will meet IMO biofouling guidelines. Supporting vessels attending site will have a BMP and BRB.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
		17 January 2020	• The *BAM Act 2007* is not mentioned in *Table 5-3: Prelude FLNG Environment Plan Relevant Persons and Consultation Process* • Typo in Table 5-3 relating to DPIRD entry "They administer the *Fish Resources Management Act 1984*" • Table 9-33: ALARP evaluation of IMS risk control measures ○ Suggest "Administrative and Procedural controls" for supporting vessels which aligns with proposed "NOPSEMA Offshore Support Vessel Reference Case" process. IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP. Suggest supporting vessels encouraged to have vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP. Application of an Antifoulant coating is only one mitigation action, of a 'best practice' IMO biofouling guidance approach. • DPIRD clarified contact information required in draft Prelude EP. DPIRD requested clarification on a statement in draft EP (page 224) "Low Risk Biosecurity Status Letter from the Department of Agriculture and Water Resources (DAWR)." The clarification related to the statement applying only the Prelude FLNG topside.	Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP. Application of an Antifoulant coating is only one mitigation action, of a 'best practice' IMO biofouling guidance approach.	Shell acknowledged this claim. However no update to the EP is proposed.

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP11	Department of Primary Industries and Regional Development NT		No response received	No claim or objection received.	Not applicable
RP12	WA Department of Biodiversity, Conservation & Attractions	19 December 2019	Email received requesting we provide future notifications to EMBAdmin@dbca.wa.gov.au.	No claim or objection received.	Not applicable
RP13	WA Department of Transport (DOT)	07 November 2019 19 November 2019 19 December 2019 07 January 2020 21 January 2020	Requested clarification on reasoning for changes in worst credible spill scenarios. Requested to correct some incorrect references related to the DOT IGN. Clarification requested around some roles and responsibilities. Requested information of modelling outputs. Clarification requested around the basis for worst predicted waste volumes from shoreline contact. Detail of cost recovery arrangements requested. Clarification requested on limitations around scientific monitoring. Clarification requested on dispersant types to be used. More information requested on training requirements of responders. Request for modelling information Clarification on modelling information provided No further question from DoT at this time.	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP75	Director of National Parks	20 December 2019	Email received confirming that planned activities do not overlap any Australian Marine Parks and no authorisation requirements from the DNP are required. Noted emergency response notification process to DNP if there are emergency oil/gas pollution incidents which occur within a marine park or are likely to impact on a marine park.	No claim or objection received.	Not applicable Confirmation that Shell's emergency response arrangements include relevant details and meet notification requirements.
		Commonwealth Fisheries			
RP15 – RP22	North West Slope Trawl Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP23	Southern Bluefin Tuna Fishery		No response received	No claim or objection received.	Not applicable
RP24	Western Tuna & Billfish Fishery		No response received	No claim or objection received.	Not applicable
		WA State Fisheries			
RP30 – RP56	Mackeral Managed Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP57 – RP59	North Coast Shark Fishery License Holders		No response received	No claim or objection received.	Not applicable
RP60 – RP67	Northern Demersal Scalefish Fishery License Holders		Email received from one license holder to say that the assumptions are reasonable.	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP68	Pearl Producers Association (PPA)		No response received		Not applicable
RP69 – RP71	West Coast Deep Sea Fishery License Holders		Email received from one license holder to explain what they do. No further comments noted.	No claim or objection received.	Not applicable
RP72	Western Australian Fishing Industry Council (WAFIC)	19 November 2019 21 November 2019 26 November 2019 19 December 2019	WAFIC notes that by and large for almost all EPs that the commercial fishing sector is the only "relevant potentially affected party" to operations as described in an environment plan. The information you have sent above regarding the revised and updated Prelude EP is not specific enough to potentially affected commercial fisheries. Please revert with the bespoke information, appropriate and relevant for a potentially affected party. Appreciate that for Prelude the key commercial fishing stakeholders are licence holders in the Northern Demersal Scalefish Fishery. You have noted that there is low fishing effort – please clarify what you mean by "low". Many thanks for the bespoke updated information, thank you also for on sending to NDSF fishers.	No claim or objection received.	Not applicable
		Industry			
RP73	INPEX		No response received	No claim or objection received.	Not applicable

Stakeholder ID	Stakeholder	Dates	Summary of Each Stakeholder Response	Assessment of Merit of Claims or Objections	Summary of Shell's Response to Objections and Claims
RP74	Finder No 13 Pty Ltd		No response received	No claim or objection received.	Not applicable

5.2.7 Ongoing Consultation

Shell will uphold its commitments to ensuring Relevant Persons continue to be consulted throughout the five-year duration of this EP through a number of activities detailed in Table 5-6. Consultations will be tailored to the specific functions, interests or activities of the stakeholders.

Table 5-6: Ongoing Consultation Activities

Activity	Description
Monthly Meeting Implemented	Monthly meeting attended by HSSE and EGR representatives to track and assess consultation and EP compliance, manage requests for information and claims and objections. Set agenda with actions tracked in Commitments Register.
Updated Commitments Register	Lists Relevant Persons, details consultation commitments as per EP Consultation Strategy and tracks consultation, and outlines EP compliance actions. Holds actions from monthly meetings.
Ongoing Consultation Procedure	Details the procedure of ongoing consultation with Relevant Persons.
Updates to Claims and Objections Process	Introduction of Shell's global system for reporting and follow up on complaints. Identified Claims or Objections will be tracked within this system. Failure to close out complaints in the system results in escalation to senior management and risks a breach of Shell's social performance standards.

Shell's 'management of change' process will also ensure that any material changes to the activity scope will trigger engagement with those who may be impacted, with periodic internal compliance/assurance checks in place in line with good industry practice.

Shell will ensure any claims or objections, or feedback, from the ongoing consultation is processed as per Shell's internal claims process, and any required follow-up action will be managed appropriately.

6.0 Description of the Activity

6.1 Scope of the EP

This Environment Plan covers the following activities within the Operational Area (Figure 6-1) located within permit area WA-44-L and infrastructure license WA-2-IL:

- Operations and maintenance turnarounds of the FLNG and subsea facilities
- Operation within the designated safety zone of the installation, support, supply and in-field support vessels and helicopters required for the offshore works, commissioning & maintenance activities and operate phase
- Product offtake tankers or bunkering vessels only when they are attached to the Prelude facility (considered as petroleum activity)
- Well intervention activities using a light well intervention vessel

- Inspections, maintenance and repairs of systems and subsea infrastructure
- Installation, commissioning and startup activities for future tie-ins (e.g. the Crux facility)
- Brownfield FLNG tie-in from the Prelude field
- Emergency Response events.

Non-petroleum activities such as environmental field monitoring or metocean studies are outside of the scope of this EP.

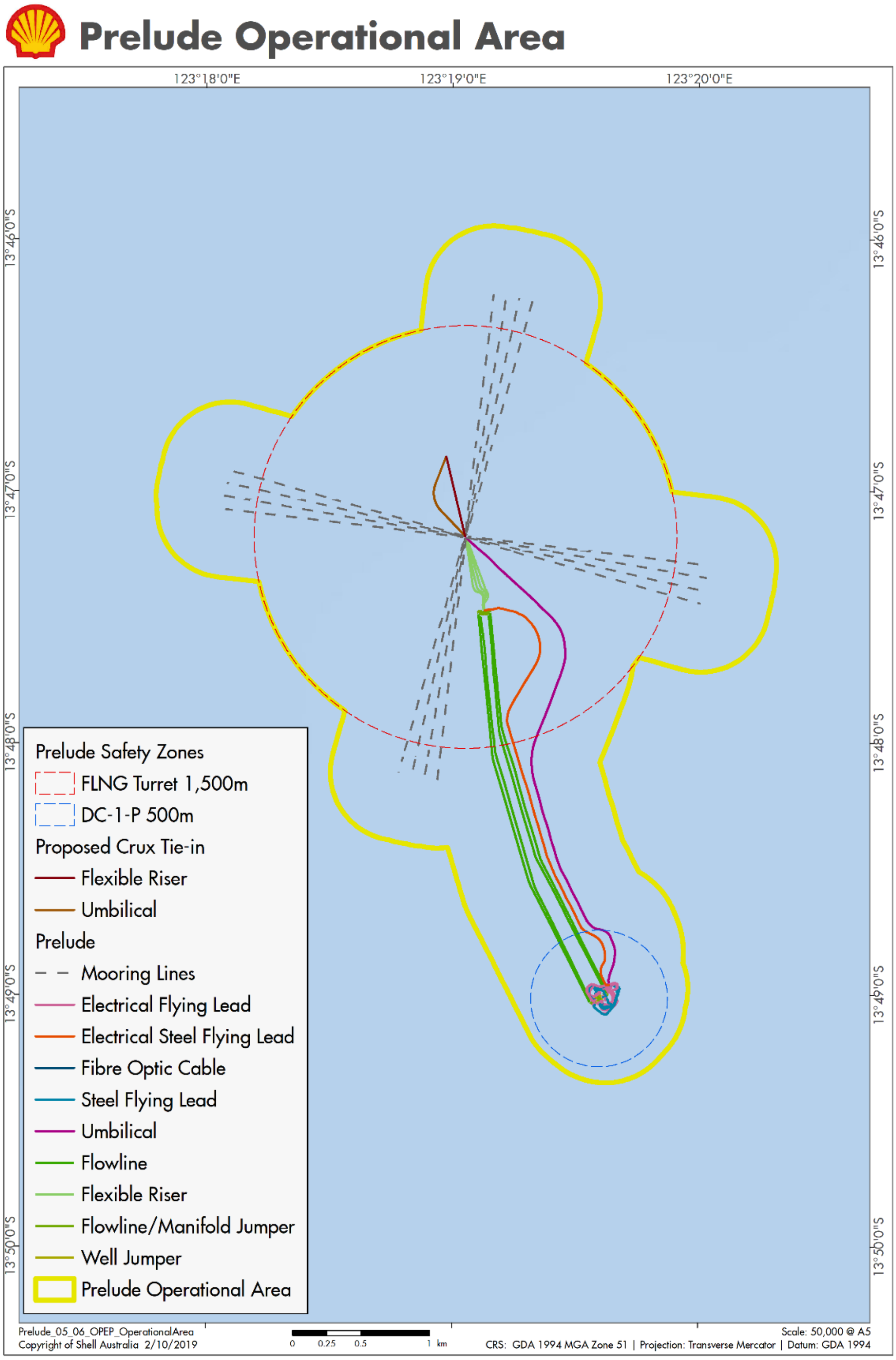


Figure 6-1: Prelude EP Operational Area

This EP does not include the general transit of vessels to or from the Operational Area. These activities will be undertaken in accordance with relevant maritime legislation, such as the Commonwealth Navigation Act 2012, and are within the jurisdiction of

AMSA. In addition, helicopter activities outside of a PSZ are not defined as petroleum activities. Therefore, activities undertaken by the vessels and helicopters which are not carrying out petroleum activities are not considered in this EP. Any impacts and risks outside of these activities are provided for via the HSSE and SP Control Framework, outside of the formal EP acceptance and implementation process, to support the transparent, whole-of-project assessment process.

6.2 Location and Timing

The Prelude FLNG Project is in WA-44-L, in Commonwealth marine waters, 200km offshore northwest Australia and 460km north-north east of Broome (Figure 6-2), in 237m from Mean Sea Level (MSL) water depth.

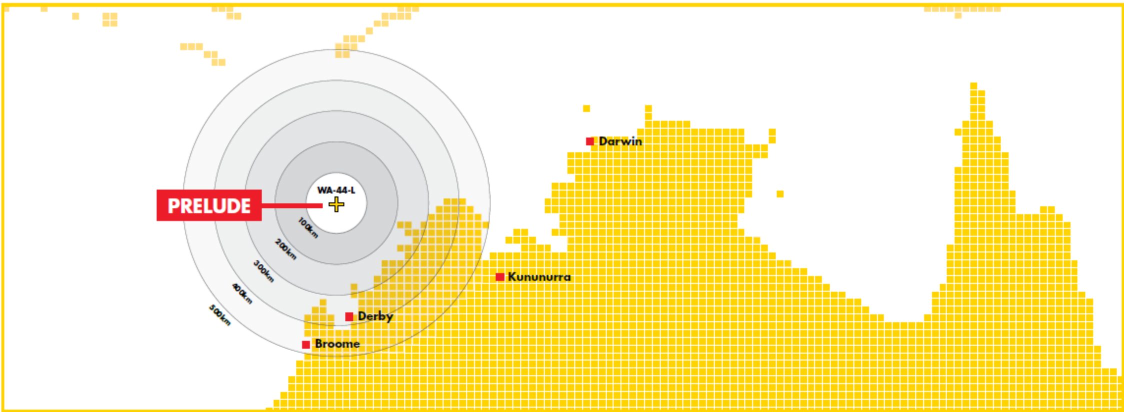


Figure 6-2: Location of Prelude (Permit Area WA-44-L)

The Prelude FLNG facility was towed from South Korea where it was constructed and partially commissioned, and arrived in field in July 2017. The installation, hook-up and commissioning occurred upon arrival of the FLNG and then the facility reached its ready for start-up (RFSU) milestone by introducing hydrocarbons from the wells on 26 Dec 2018. Steady state operation is defined as once the facility name plate capacity (i.e. design capacity) is reached following the completion of the well cleanup and performance testing process. The Prelude FLNG facility is designed to stay on location and operate for at least 25 years.

LNG, LPG and condensate will be transferred to offtake tankers with the following estimated frequency:

- LNG – every week
- LPG – every month
- Condensate – every 2 weeks.

6.3 Prelude FLNG Facility Overview

The next few sections provide a high-level description of the layout of the Prelude FLNG facility. There is more detailed information in Appendix A: Detailed Facility Description.

The Prelude FLNG facility (Figure 6-3) is a turret moored offshore floating production facility with gas processing and liquefaction units. The facility includes LNG, LPG and condensate storage as well as facilities for exporting these products to offtake carriers.

It is connected to the gas reservoir and wells via flexible risers routed to the turret. All reservoir, subsea control, processing, storage and loading are controlled from the Prelude FLNG facility. The facility will remain on station for 25 years without dry docking and is a permanently manned facility. Periodic major maintenance or turnarounds will be carried out in-field during operate phase. Figure 6-4 shows the Prelude field layout.

Prelude has one drill centre with two 6-slot manifolds and seven production wells at the drill centre DC-1P. The drill centre is located approximately 3km south of the Prelude FLNG facility. The Prelude FLNG facility is connected to the gas reservoir via four 12" flowlines connecting the production manifolds to the riser base manifold.

Each flow path to the Prelude FLNG facility, consisting of flowlines and flexible risers, is equipped with a Fail Close Riser Base Valve (FCRBV) at the Riser Base Manifold (RBM), located at a horizontal distance of 550m from the centre of the turret, to isolate the Prelude FLNG facility from the flowlines inventory.

The Prelude FLNG facility is moored using 16 mooring lines connected to piles grouped into four quadrants. A Fibre Optic (FO) cable connects the Prelude FLNG facility to the Australian FO network onshore.

The Prelude FLNG facility itself is 488m long, 74m wide and has an operating draft of 19.1m and is permanently moored with weathervaning capability. The main elements of the Prelude FLNG facility are:

- An internal turret, which permanently moors the Prelude FLNG facility to the sea-bed via a catenary mooring system and provides interface with subsea systems
- Topsides containing all process units & part of the utilities systems
- A substructure with all necessary marine facilities, accommodation, cargo containment systems, and the remainder of the utilities systems:
    - Storage Tanks
    - Aft Machinery Space & Fwd Machinery Space
    - Side by Side Mooring and LNG/LPG Offloading
    - Accommodation / Living Quarters
    - Tandem Mooring and Condensate offloading
    - Water Intake Risers.

The substructure is separated from the Topsides by the main deck, on which piping systems such as cooling water, steam, fuel gas, rundown and loading lines are located. Topsides equipment is arranged in large modules over a series of process decks.

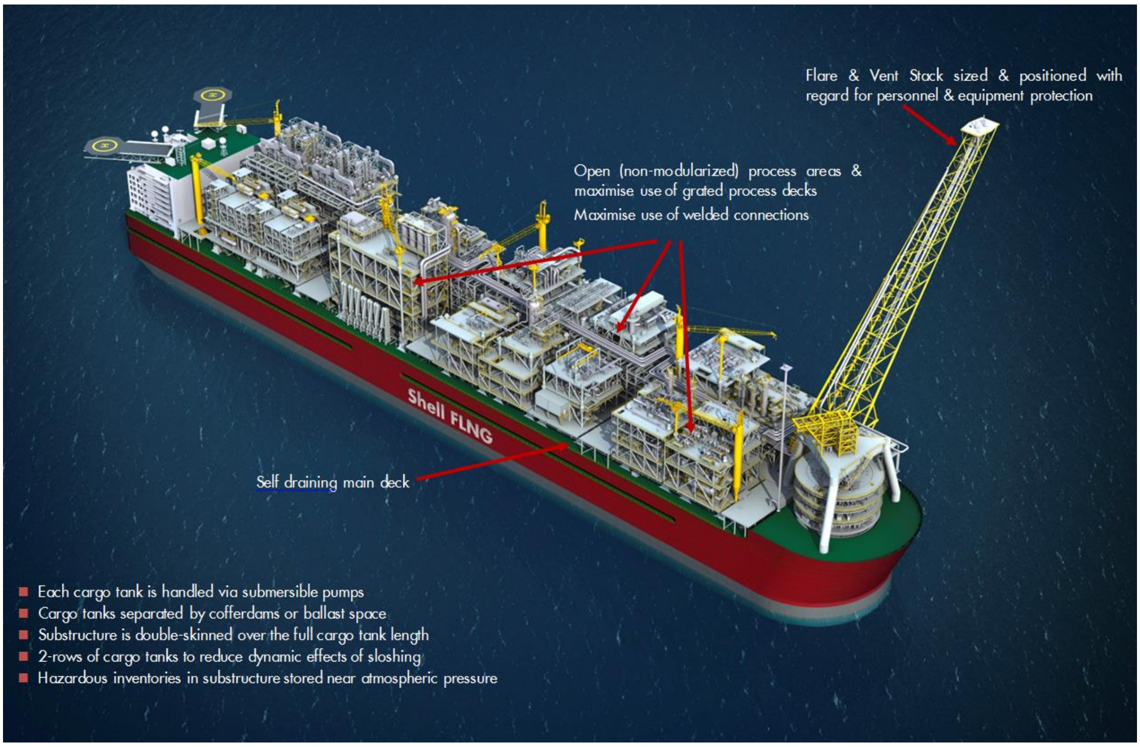
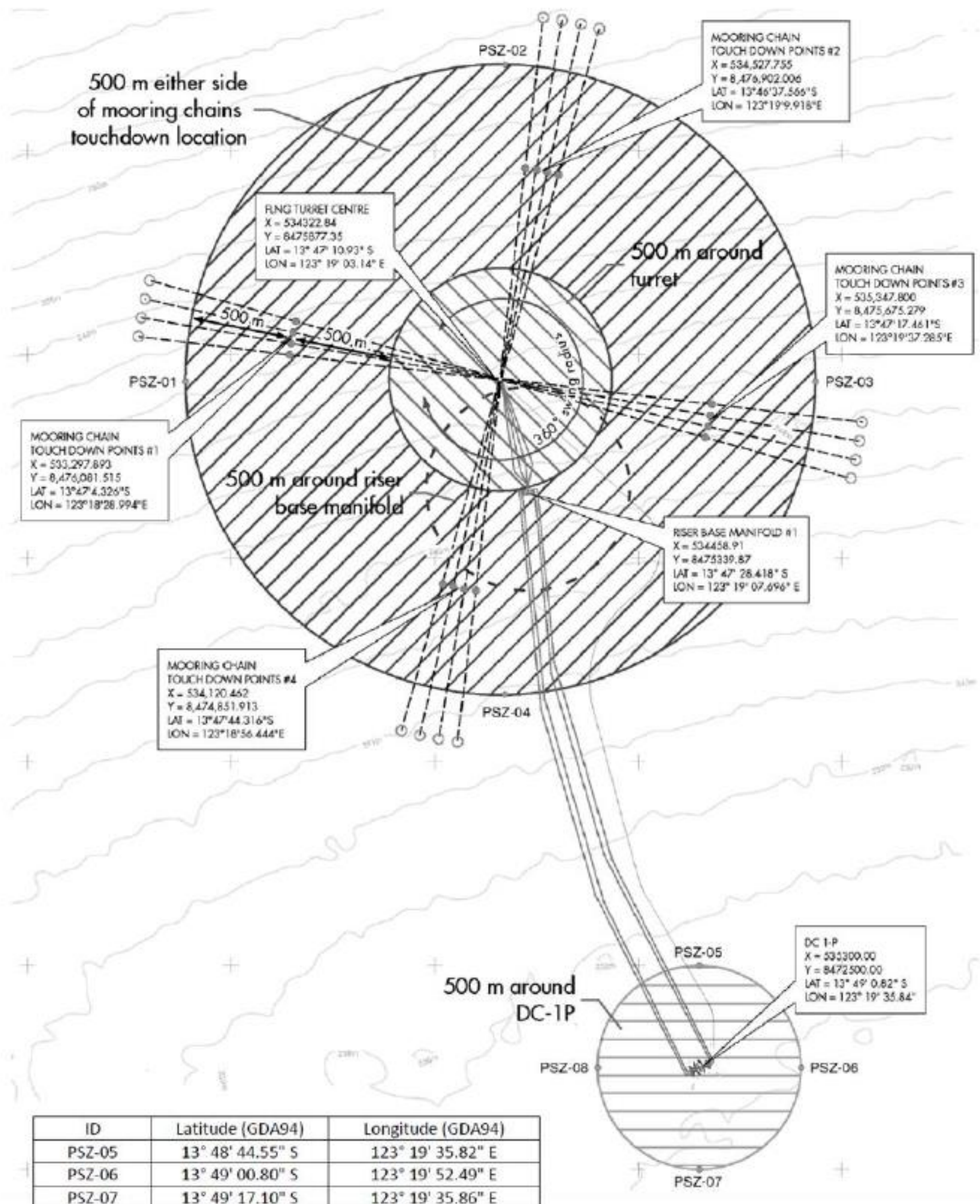


Figure 6-3: Overview of the Prelude FLNG Facility

6.3.1 Prelude Field Safety Zones

Prelude field safety zones are published under Commonwealth of Australia Gazette Notice: A441884 which extend around both the well infrastructure equipment and the Prelude FLNG facility as shown in Figure 6-4.

ID	Latitude (GDA94)	Longitude (GDA94)
PSZ-01	13° 47' 11.40" S	123° 18' 11.61" E
PSZ-02	13° 46' 20.57" S	123° 19' 03.74" E
PSZ-03	13° 47' 11.26" S	123° 19' 54.65" E
PSZ-04	13° 48' 01.29" S	123° 19' 03.88" E



ID	Latitude (GDA94)	Longitude (GDA94)
PSZ-05	13° 48' 44.55" S	123° 19' 35.82" E
PSZ-06	13° 49' 00.80" S	123° 19' 52.49" E
PSZ-07	13° 49' 17.10" S	123° 19' 35.86" E
PSZ-08	13° 49' 00.85" S	123° 19' 19.19" E

Figure 6-4: Prelude Field Layout and Safety Zones

6.3.2 Subsea Facilities

The subsea facilities are shown in Figure 2-1 with brief descriptions in Table 6-1.

Table 6-1: Prelude Subsea Equipment Description

Subsea Facility	Description
Wells	• Drilled from a single drill centre • 7 highly deviated/sub-horizontal (85deg) wells • Each well can deliver up to 200 MMscf/d (Note: Dry (water free) gas flow rates) • SCSSV installed in each well

Subsea Xmas Tree	• 690bar (10,000psi) 7" Enhanced Vertical Deepwater Tree (EVDT), consisting of the following:
	  ○ Production choke valve (PCV)
	  ○ Subsea venturi flowmeter (VFM)
	  ○ Subsea control module (SCM)
	  ○ Pressure and temperature sensors
	  ○ Chemical injection ports (for MEG and SI/PPD)

Jumper, Flowlines & Production Manifold	• Two 6-slot production manifolds provide tie-in for up to 12 gas production wells (five spare slots) • Manifolds have dual headers • Flow from each well can be directed to either header • Each manifold is connected to two flowlines (approx. 3km in length) and the manifolds are connected via the manifold jumpers together to provide dual looped flow paths • Dedicated SCM on each production manifold
Riser Base Manifold (RBM)	• Flowlines are connected to the four 12" flexible production risers to the Prelude FLNG facility via the RBM • Fail Close Riser Base Valve (FCRBV) installed at the RBM for each of the risers • Dedicated SCM on the RBM
Production Risers	• Prelude FLNG facility process modules are connected to the subsea facilities via four flexible risers connected to the turret • Design pressure of 400 barg and temperature of -20 / 128°C • Material for the critical pressure sheath layer (i.e. PVDF) is capable of handling Prelude fluid and design temperature • Installed in a lazy wave configuration with allowance for excursions around the Datum • End connections of the risers are fitted with bend stiffener to prevent damage to the riser's structure from over bending • Flexible risers are anchored at the Prelude FLNG facility using standard hang-off devices • A Riser Emergency Shutdown Valve (RESDV) is installed at the top of each riser on board the Prelude FLNG facility • Riser vent gas monitoring is provided to monitor diffusion of gas through the pressure sheath into the flexible pipe annulus
Umbilical and Subsea Distribution	• A dynamic control umbilical links the Prelude FLNG facility to the subsea system providing hydraulic, electrical and chemical services, and signal and power control communications to the subsea system • Designed to support eight production wells • End connection is fitted with a bend stiffener to prevent damage to the umbilical structure from over bending

6.3.3 Turret Mooring System

Figure 6-4, the Turret Mooring System (TMS) is a major element that provides the station keeping function for the Prelude FLNG facility and connects the subsea infrastructure with the topsides process modules. The Prelude FLNG facility rotates freely about the turret subject to the influences of the prevailing winds, waves and currents, naturally adopting a heading (termed weathervaning). This weathervaning requires the use of a swivel stack to transfer the production stream, chemicals, power, and communications signals between the Prelude FLNG facility and the subsea equipment.

The Prelude FLNG facility is permanently moored and designed for cyclonic conditions offshore NW Australia. The mooring system is designed to withstand the design 10,000 years return period cyclone event when all lines are intact. In conditions, up to and including the 100 years return period cyclone, the mooring system offers redundancy following failure of any one mooring line, such that in any principal loading condition will not lead to progressive failure of the mooring system or exceed riser design limits.

6.3.4 Turret

The turret, shown in Figure 6-5, is an internal type turret and is located completely within the boundary of the substructure at the bow of the facility. All risers and mooring lines pass through the centre of the turret. This design enables mooring chains and risers to be protected from ship collision and direct wave actions.

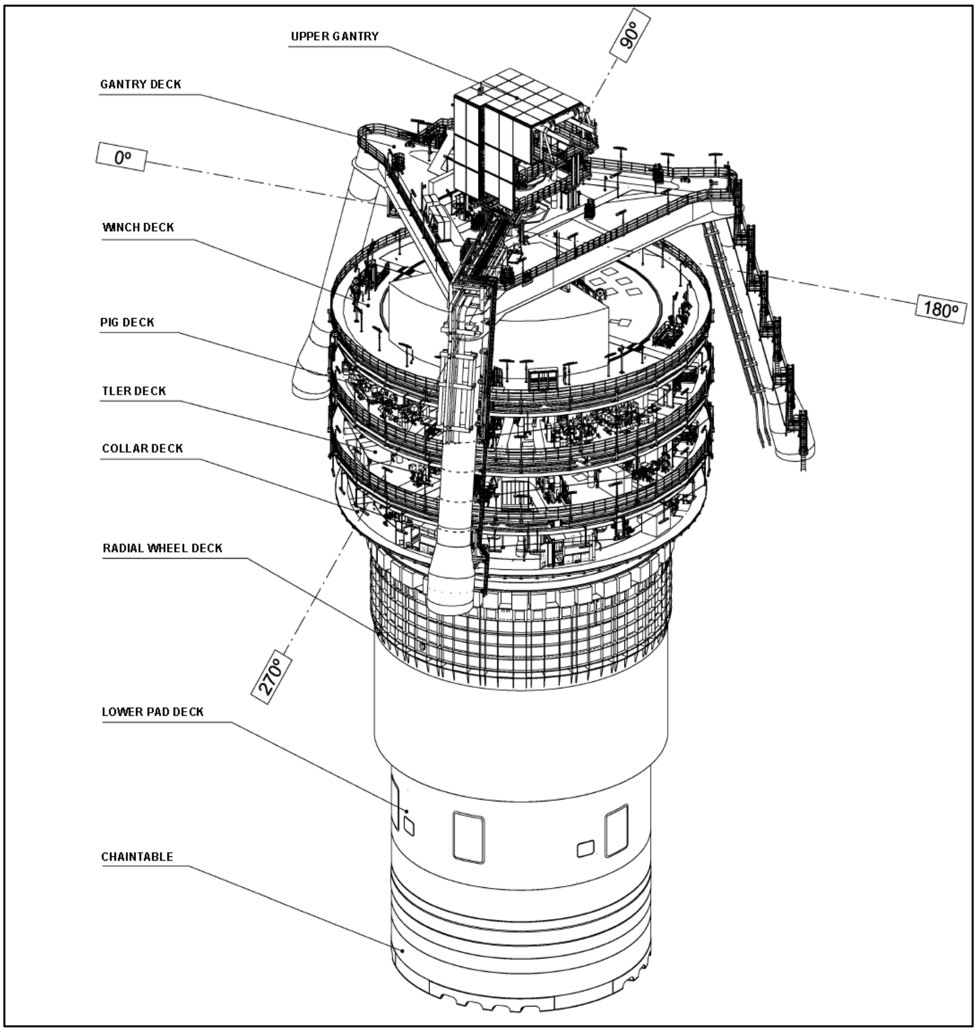


Figure 6-5: Turret 3D View

6.3.5 Topsides and Main Deck

The process units and other key utility units are located above the main deck in the form of modules, collectively called the Topsides. The process and utility units on the Topsides are split-up in 8 modules, further sub-divided into 14 sub-modules, 8 infill areas, lay-down areas, hull pipe rack with maintenance route, and 1 flare tower including the marine and CO_2 vent. Figure 6-6 shows a plan view of Prelude FLNG facility detailing the location of the process and utility sub-modules and the key equipment contained per sub-module.

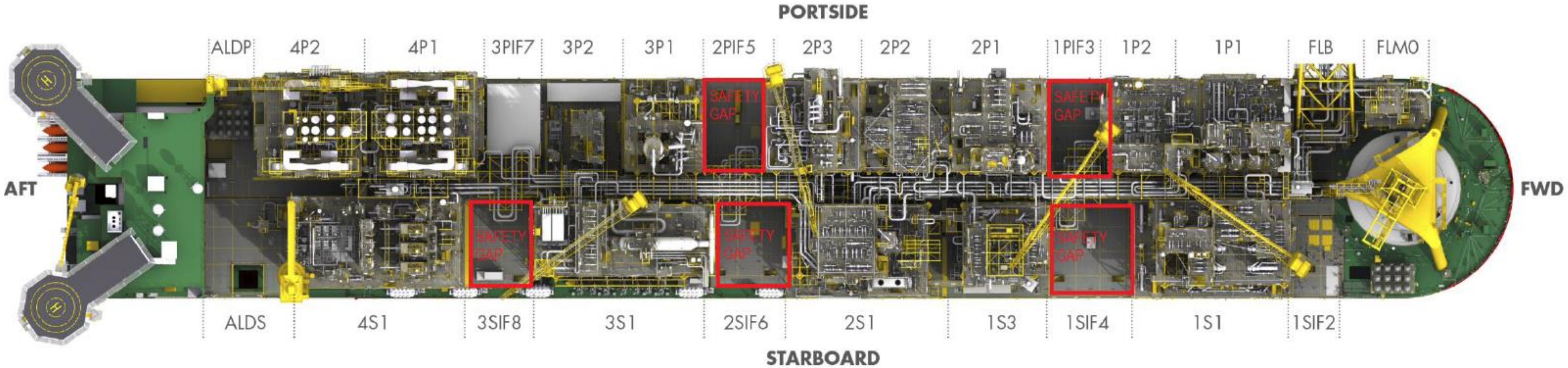
The process fluid from the wells passes through the Turret module to the processing module on the Topsides. The key function and equipment per modules is described below:

- **Module 1S (1S1, 1S3)** contains the inlet facilities and primarily separates the well stream into gas and liquid flows. This unit receives and conditions the feed gas and liquid hence located close to the turret area. Module 1S3 includes installed depletion compressor and its auxiliaries, which shall not be operated during the early phase of the well life.

- **Module 2S1** contains the acid gas recovery unit (AGRU) absorption column, gas dehydration (mole sieve dryers) & mercury removal (Hg guard bed) units. The regeneration facilities for the acid gas removal unit are located in module 3P1.
- **Module 1P (1P1, 1P2)** contains the NGL extraction, fractionation and booster compression units. Because of the amount of light liquid hydrocarbons (C2, C3, C4) and lower integration requirement with other units, the fractionation unit is located as far from the accommodation block as possible. For the same reason, this unit is located in the opposite side of the mooring location of the LNG/LPG carrier (when alongside). The condensers and accumulators are located on an elevated level to provide sufficient suction head (NPSH) for the pumps. All pumps are currently located underneath these vessels at the lowest level in the module.
- **Module 2P (2P1, 2P2, 2P3)** contains the liquefaction unit. The mixed refrigerant (MR) part in module 2P1 consists of the main cryogenic heat exchanger (MCHE) and condensing steam turbine driven MR compressor with its coolers and knockout facilities. The pre-cool mixed refrigerant (PMR) part in module 2P3 consists of the condensing steam turbine driven PMR compressor with its de-superheaters and condensers and knockout facilities. The PMR receiver and main pre-cooler (LP, MP, HP) i.e. coil wound heat exchangers are located in module 2P2 in between the MR and PMR part.
- **Module 3P (3P1, 3P2)** contains the AGRU stripping section, MEG regeneration and reclamation unit. The 3P1 module contains the solvent regeneration column, LP steam heated re-boilers, heat exchangers, filters and pumps. The solvent drain vessel is located on the main deck under 2S1 and solvent storage tanks are located in the hull. Module 3P2 contains the MEG regeneration, reclamation unit and nitrogen booster compressor and high pressure nitrogen vessel. The nitrogen booster compressor only operates to top-up the high pressure nitrogen vessel.
- **Module 3S1** contains the end-flash unit. This module contains the end flash vessel and associated end flash compressor. The fuel gas system with fuel gas heaters is located on an elevated deck. This module also contains the offloading analyser and metering stations. The side-by-side offloading loading arms and associated manifolds are located at main deck level. This module also contains the electrochlorination unit and CCW2 expansion vessel on the top deck.
- **Module 4P (4P1, 4P2)** contains seven marine steam boilers.
- **Module 4S1** contains the low pressure nitrogen generation unit, de-aerators, CCW2/3 expansion vessel, air compressor. These relatively low risk units (i.e. 4P and 4S) are located in the area between the accommodation and the process area.

The flare boom length is 155m, inclined by 40° portside perpendicular to the hull. The flare knock out vessels and associated equipment are located adjacent to the flare stack structure in module FLM0.

Module, i.e. Process Deck A and above					
Infills (PIF) & Laydown Area	**4P1, 4P2 Steam Generation**	**3P1, 3P2 AGRU Stripping Side, MEG Regen & Reclaim**	**2P1, 2P2, 2P3 Liquefaction**	**1P1, 1P2 NGL Extraction & Fractionation, Booster Compressors**	**FLM0, FLB Flare Module, Flare Stack**
• 1PIF1 • 1PIF3 (Safety Gap) • 2PIF5 (Safety Gap) • 3PIF7 (LER) • Aft Laydown Portside - ALDP	• Steam Generation (U40000), • 4P1 - Marine Steam Boilers 1-4, • 4P2 - Marine Steam Boilers 5-7, • HP-LP PRS, Distribution • Boiler Blowdown vessels (U41000)	• 3P1 - AGRU (U11000), Solvent Regeneration and Filtration • 3P1 - LP PCL Flash Vessel & Pumps (U41000) • 3P2 - MEG Regeneration & Reclamation (U52000), High Pressure N_2 Compressor (U48000)	• Liquefaction Unit (U14000), 2P1 - NG Main Cryogenic Exchanger, MR compressor, 2P2 - PMR Reclaimer, NG Pre-Coolers (HP, MP, LP), 2P3 - PMR Compressor, • 2P2 - LNG vaporizer &Pump, Maintenance Compressor (U34000)	• 1P1 - NGL Extraction (U14000) NGL extraction column • 1P1 - Fractionation (U15000), De-Ethaniser, De-Propaniser, De-Butaniser • 1P1 - LP PCH Flash Vessel & Pumps (U41000) • 1P2 - NG Expander/ Re-compressor, NG Booster Compressor, Defrost gas heater (U14000)	• FLM0 - Flare Module contains the flare KO drums, stabilizer vessels (U63000) • FLB - Flare stack including marine and CO_2 Vents
Main Deck to Process Deck A (below each Module)					
	• Condensate offloading pumps • Open Non-hazardous drain vessel	• Butane offloading pump hatch • Open hazardous drain vessel and pumps	• LNG Offloading pump hatch • Propane offloading pump hatch	• CO_2 snuffing Skid • LP PCH transfer pumps • LNG Offloading pump hatch	• Wet Stabilizer Vessel • Ethane Refrigerant pump hatch • Propane/PMR Refrigerant pump hatch • Offspec reprocessing pumps



Module, i.e. Process Deck A and above				
Infills (SIF) & Laydown Area	**4S1 Utilities**	**3S1 End Flash, Boil Off and Fuel Gas**	**2S1, 1S3 AGRU Absorption Side Gas Dehydration and Hg Removal, Inlet Facilities**	**1S1, 1S3 Inlet Facilities**
• 1SIF2 • 1SIF4 (Safety Gap) • 2SIF6 (Safety Gap) • 3SIF8 (Safety Gap) • Aft Laydown Starboard - ALDS	• Service/Portable & Demin Water (U-43000), De-aerators • CCW2 Circulation Pumps (U45000), • CCW3 Expansion Vessels (U45000), • Air Compressor, IA generation (U47000), • N_2 Generation Unit (U48000)	• Liquefaction Unit (U14000), LNG Expander, End Flash Column & Compressor • Fuel Gas System (U44000), • CCW2 Expansion Vessel (U-45000), • Electrochlorination unit (U46000), • Propane/Butane metering (U35000) • Condensate metering (U36000)	• AGRU (U11000), Absorption Section • Molecular Sieve Dehydration Unit (U13000), • Mercury Removal Unit (U13500), • HP PCL Flash Vessel (U41000)	• 1S1, 1S3 - Inlet Facility (U10000), • HP Separators, LP Separator, Depletion Compressor, Condensate Stabilizer 1&2, Condensate Stabilizer Overhead compressor, • Produced Water Flash Gas package (U64000), • LER • Flare Maintenance Vent (U63000)
Main Deck to Process Deck A (below each Module)				
	• Condensate offloading pumps	• LPG/LNG offloading arms (U34000/ U35000) • Propane/Butane offloading pump hatches • Rich MEG transfer pump	• LNG Offloading pump hatches • Open hazardous drain vessel and pumps • Solvent Drain Vessel	• FWD rich MEG storage tank transfer pump • PW flash gas vessel pump and slop oil pump • Open hazardous drain vessel and pumps • PW flash gas vessel

Figure 6-6: Main Deck and Topsides Layout Plan

6.3.6 Water Intake Risers

The Prelude FLNG facility uses cold cooling water to increase the efficiency of the liquefaction process efficiency and reduce plot space. Water is required to be pumped from an average water depth of 170 m to meet the closed cooling water circuit demand.

6.3.7 Substructure

Storage Tank Layout

The following tanks are installed in the substructure:

- 6 LNG storage tanks
- 4 LPG storage Tanks
- 6 Condensate storage tanks
- 1 Produced water tank
- 2 Off spec tanks.
- 2 Rich MEG tanks plus 1 Fwd Rich MEG tank
- 2 Lean MEG tanks
- 1 Solvent Storage Tank
- 1 Water Wash Storage Tank
- 1 Chemical Spills Collection Tank
- Slop tanks
- 1 PMR Tank
- 1 Ethane Tank.

The substructure is double hulled on each side extending over the full length of the storage tanks. LNG, LPG and Condensate storage tanks are located inboard of segregated ballast tanks covering the full length of the storage area. The tanks are fed directly from the Topsides rundown system.

The port and starboard LNG, LPG and Condensate tanks are separated from each other by a void space or ballast tank. The design of the hull structure is such that LNG, LPG and condensate storage tanks are separated from the plant hazardous area by a main deck which is designed to withstand explosion overpressure, jet fire and cryogenic spills. The LNG, LPG tank tops are double deck type arrangement with all piping systems above the main deck designed to survive blast overpressure load. There are no flange connections in the piping within the double deck. Heating system is installed to heat the transverse cofferdams and the upper portion of centreline water ballast tanks surrounding the cargo tanks to maintain the temperature of the structure.

Aft Machinery Spaces & Fwd Machinery Spaces

The aft machinery space is enclosed within the hull with facilities arranged over 7 decks and are mechanically ventilated. The machinery space is provided with normal access by stairways from the accommodation and the main deck. An enclosed mechanically ventilated space is located in the forward part of the Prelude FLNG facility to accommodate equipment associated with the turret and effluent treatment operation.

Side-by-Side Mooring and LNG/LPG Offloading/Import

LNG/LPG carriers are moored alongside the starboard side of the Prelude FLNG facility utilising mooring lines and separated via the fenders.

Condensate Offloading via Tandem mooring

A tandem mooring and offloading system is fitted at the stern of Prelude FLNG facility for offloading condensate cargo to a condensate tanker. The condensate tanker is moored to the Prelude FLNG facility by a tandem mooring hawser configuration. When not in use, the hawser is recovered.

Accommodation / Living Quarters (LQ)

The LQ houses 170 cabins. The cabins are designed as single rooms with the option to convert to double occupancy, therefore, a maximum of 340 POB can be accommodated. Each cabin has a private shower/toilet facility.

Helideck(s) and Refuelling System

Two helidecks, each with a helicopter parking area are located above the accommodation/LQ. The helideck pancake is self-draining “Safedeck” type made of aluminium.

Helicopter refuelling package (i.e. tote tank/storage tank/recycle system/pumps) and associated firefighting system are located on the top of the accommodation. Dispenser cabinets comprising of the fuelling reel, filter and sampling unit are provided at each helideck.

Provision of heli-fuel for the helicopter re-fuelling station is by way of 3 x 4000L portable tote tanks.

6.4 Operational Activities

The following are the activities conducted on the facility to ensure safe production of hydrocarbon products:

- Production Operations - Activities to ensure that operations of the facility are conducted within their defined envelopes. This includes facility hydrocarbon commissioning, start-up and ramp-up (SURU) activities.
- Maintenance and Inspection - Activities to inspect and maintain hardware and equipment integrity and reliability.
- Underwater Inspection, Maintenance and Repair - Activities to inspect, maintain and/or repair the underwater/subsea facilities.
- Services - Includes the following activities:
    - Maritime and Terminal Operations - activities relating to the management of access and/or movement of marine vessels within the Safety Zone; and the management of product offloading/import activities
    - Helicopter Operations
    - Management of lifting and hoisting and deck services on the facility
    - Facility catering services.

6.4.1 Maintenance, Shutdowns and/or Turnarounds

Regular maintenance activities are carried out on a daily basis on the Facility. Facility maintenance shutdowns and/or turnarounds are planned at regular frequencies to conduct inspection, maintenance and/or repair works that could not be completed during production operations. During a facility shutdown and/or turnaround, the topsides facility is predominantly shutdown and depressurised.

Further, maintenance shutdowns/turnarounds are supported by services activities such as helicopter operations and maritime activities including supply boat activities and bunkering.

Temporary facilities for accommodating additional personnel, wastes accumulated and materials may be likely required during major turnarounds, however, no other significantly different environmental risks from those described in Section 9 are expected. A risk assessment and supporting demonstration that impacts and risks are managed to ALARP and Acceptable levels will be conducted for any temporary liquid discharges or air emissions generated by maintenance activities.

6.4.2 Preservation and Maintenance of Subsea Equipment

The Prelude Preservation and Storage strategy (2000-005-S001-SS01-G00000-UA-5980-00004) gives an overview of the approach that is used to ensure that project equipment is managed appropriately, including both dry and wet storage, prior to commencing operations.

The requirement for maintenance activities on the subsea equipment are expected to be limited because of the material selected for the equipment. However, as a result of the high pressures and naturally occurring metocean conditions in which subsea infrastructure operates, inspection and maintenance are required to ensure the integrity of the infrastructure and identify any problems before they present a risk of loss of containment or asset damage.

The majority of maintenance activities comprise general visual non-intrusive inspections using ROVs such as cathodic protection probe inspection and checks, marine growth checks, seabed and free span checking and measurements, azimuth and mooring surveys.

Should repair and/or replacement of subsea infrastructure be required, a detailed risk assessment will be done prior to the repair activity. Repair activities are those required when a subsea system or component is degraded, damaged or has deteriorated to a level outside of acceptance limits as defined by design codes.

During these maintenance activities, minimal fluids are released as lines are depressurised and flushed prior to any intervention activities.

Marine Growth Covers (MGC) are provided for all critical Subsea hardware assets with ROV Interfaces. The objectives of the MGCs are to reduce the amount of soft growth and thus reduce the time required for the ROV to clean the interfaces required during the commissioning phase and during an intervention in the operating life of the asset. Excess marine growth removal maybe undertaken on Prelude subsea facilities with an ROV. Various techniques for marine growth removal include:

- Water jetting – use of high pressure water
- Brush systems – use brushes attached to an ROV
- Use of chemicals
- Sand/abrasive blasting.

Minor chemical discharge may be associated with marine growth removal, although non-chemical method is preferred.

An Underwater Services Contract is in place to execute all subsea/underwater inspections and maintenance activities. Subsea activities are typically performed from a support installation vessel via one or more ROVs. Typical support vessels use a DP system to avoid anchoring. The Underwater Services Contract manages the scope for planning, preparing and executing routine and ad-hoc underwater intervention and inspection for Prelude FLNG Moorings and Subsea Hardware. The contractor is responsible for the following:

- Perform engineering and develop procedures associated with the intervention and inspection activities
- Supply appropriate vessel(s) and associated support personnel
- Provision of all materials and equipment
- Undertake the intervention and inspection activities in accordance with approved procedures
- Provision of all reporting and documentation.

6.4.3 Well Intervention and Work-over

Well intervention activities can be initiated by a number of scenarios that may occur during the operations phase of a wells lifecycle. Interventions may be undertaken for reservoir surveillance, enhancing productivity, assessing wellbore condition and restoring well integrity. Well interventions may include wellhead maintenance, logging or surveys, mitigating safety critical failures (e.g. failed safety valve), and perforating the wellbore.

When top-up of the well annulus with MEG is required, up to 15bbl of MEG will be injected into the annulus in 5 – 10bbls increments (pressure dependent). After allowing the MEG to “flip” with the base oil in the annulus, annulus pressure will be bled off with returned baseoil being flushed to the surface via the flow/return umbilical. Injection of MEG and return of base oil will be repeated until the required volume of MEG has been pumped into the annulus. Returned liquids will be stored onboard the Light Well Intervention Vessel in the waste liquid tank. As this is a closed loop system, there are no planned discharges.

Well interventions and workovers are planned and executed by the Wells Delivery team, interfacing and concurring with asset groups as appropriate. The work is conducted in accordance with Prelude FLNG Permit to Work controls. Management of these activities are detailed in the Prelude Well Operation Management Plan (WOMP).

ROV(s) are used from the vessel in support of the well intervention activities. The ROV(s) are a standard work class ROV, with any specialist equipment or tooling required mounted on the ROV. An observation class ROV may also be employed to assist the work class ROV where appropriate.

6.4.4 Light Well Intervention

6.4.4.2 Light Well Intervention (LWI) Vessel Description

The following describes a typical vessel to be used for offshore well intervention activities.

Well intervention activities are executed by Light Well Intervention (LWI) vessels with an accepted vessel Safety Case for those activities consistent with the OPGGS(S) Regs 2009. Should the vessel scope demonstrate functionality or significant hazards that are not captured within the accepted vessel Safety Case scope, then a re-assessment shall be undertaken accordingly. This shall be followed by a consultation and revision to the existing vessel safety case, as required by the OPGGS(S) Regulations 2009.

Shell has framework agreements in place with a number of providers. The scope under these agreements is provision of a fully integrated LWI service including vessel, subsea intervention device (SID), ROVs, slickline/wireline services, bleed-off package services and project management under Shell's Well Engineering oversight. Having agreements in place with a number of providers improves response time to a potential well integrity issue requiring an intervention in the event the primary LWI service provider is unable to supply the requested service.

The selected LWI vessel contractor shall ensure that such a LWI vessel has the required vessel documentation accepted by the various legislative bodies for use offshore in Australian waters. More details on the specific LWI vessel used on Prelude can be found within the datasheet included in the vessel Safety Case.

Light Well Intervention Vessel Safety Critical Equipment

Safety critical equipment will be detailed in the LWI vessel safety case. Where applicable each LWI vessel safety case is reviewed by Shell in conjunction with the Prelude FLNG Safety Case (in force) to ensure that there are no omissions with regards to safety critical equipment. There are a number of key safeguards with interfaces to the Prelude FLNG Safety Case (in force) and this EP, which shall be scrutinised at this review the vessel safety case, and thereafter at the maritime vessel assurance reviews. Examples of physical safeguards that relate to environmental protection and this EP include:

- Navigation equipment and aids (including audible and visible warnings)
- Communication equipment
- Dynamic positioning system
- Lifting equipment
- Back-up power supply
- Emergency shut-down, alarm and lighting systems.

Remotely Operated Vehicle(s) (ROVs)

ROVs are used from the LWI vessel in support of the Light Well Intervention activities. The ROVs are standard work class ROVs, with any specialist equipment or tooling required mounted on the ROVs. Observation ROVs may also be employed to assist the work class ROVs where appropriate.

Subsea Intervention Device (SID)

Well interventions require well bore access into 'live' wells. A SID is deployed and utilised to allow wellbore access while maintaining well control. Basic particulars of a SID are listed below. Any selected vessel contractor shall ensure that such a SID shall meet the functionality and operability as per the approved WOMP as required by the OPGGS (Resource Management and Administration) Regulations 2011. Subsea Intervention Device (SID) typical details:

- System Working Pressure: 10,000 psi
- Umbilical pressure rating: 7,500 psi (4x ¾" (19mm) lines)
- Min Bores Size: 7-3/8" (187mm)
- SID Ram/Valve configuration: Capacity for two (2) sealing barriers in place for all well interventions

- Subsea Connector Type: 18-3/4" (476mm) H4 10,000 psi
- Subsea Intervention Lubricator Length: 60ft.

6.4.4.3 Light Well Intervention (LWI) Operational Considerations

With two well barriers in place the tree cap can be recovered. After tree cap recovery the SID will be deployed onto the subsea production tree using a heave compensated crane on the LWI vessel. After deployment of the SID onto the subsea production tree the SID will be pressure tested to Closed-In Tubing Head Pressure (CITHP) plus a margin. SID umbilicals and slickline/wireline will be compensated.

Control of the production tree valves during well entry will be via the SID umbilical system for hydraulic activated valves (unless valves are locked open during interventions) and ROV for manual operated valves.

The well suspension plug is then recovered on slickline/wireline from the LWI vessel.

The subsurface safety valve will remain closed throughout the operation unless opening the subsurface safety valve will serve to minimise operational risk. In this event, the Wells MoC process will apply. Any potential gas pressure build up between a closed subsurface safety valve and the tubing hanger plug will be bled off to a nominal value as defined in the detailed procedures.

If required, subsea production tree valve cavities and the A-annulus may be flushed/ topped with inhibited MEG from the LWI vessel. This will most likely be completed using a down line from the LWI vessel or via ROV as an alternative.

After plug recovery production tree valves will be closed and tested.

With sufficient well barriers in place the SID will be placed on the next well or recovered to the LWI vessel. A tree cap will be installed and pressure tested with an ROV.

6.4.5 Contingency Light Well Intervention

Light well interventions required on the Prelude wells, post suspension plug recovery, will in principle be the result of a well integrity issue needing an investigation or repair. Potential well intervention triggers may include:

- Completion tubing leak
- Production packer leak
- Loss of A-annulus integrity
- Subsurface safety valve functionality issues
- Subsea production tree valve leak.

Well interventions most likely require a well entry using slickline/wireline. This can be executed by a vessel with Light Well Intervention capability similar to the LWI vessel used for the planned suspension plug recovery operation. As a result, Section 6.4.4.2 Light Well Intervention (LWI) Vessel Description and all requirements and associated references are also applicable to contingency Light Well Intervention activities.

Although the in-well activities and objectives are different, the risks and hazards are effectively identical to suspension plug recovery. Hence the Commissioning & LWI Well Integrity Risk Register, detailed in Appendix 7, will apply for these operations.

Below are some of the contingency Light Well Intervention activities listed which may be applicable from suspension plug recovery through to the commissioning and production (including start-up) activities.

6.4.5.1 Slickline/Wireline interventions

The likely types of slickline/wireline intervention that may be required during the Prelude well life cycle are detailed further in this section.

6.4.5.2 Deep Set Plugs

Setting a deep-set plug would most likely be triggered by a well integrity concern, coming from a tubing or production packer leak into the A-annulus.

If the leak is in the tubing, then the most likely plug will be a slickline conveyed plug set in the nipple profile located in the completion tail pipe.

A leak of the production packer itself will require a high expansion plug set in the 7" (178mm) liner. This plug will be run on e-line and potentially requires the use of a tractor and setting tool.

6.4.5.3 Sub-Surface Safety Valve Repairs

Sub-surface safety valve functionality issues may also lead to an intervention. The most involved operation that would be attempted would be to run an insert valve. This operation involves four main slick line runs (with possible drift and check runs in between). The operational steps are:

- Run in Hole (RIH) and exercise the sub surface safety valve. This involves shifting the sleeve up and down using a dedicated wireline tool.
- RIH with a lock open tool. This trip involves stroking the sleeve of the sub surface safety valve down and locking it in this position using a dedicated wireline tool.
- RIH with a punch/ communication tool. This dedicated wireline tool will create hydraulic communication with the sub surface safety valve control line.
- RIH with the insert safety valve. The valve is deployed on a lock that sets in the nipple profile above the subsurface safety valve. With the lock set in the profile the valve straddles the punched port allowing the control fluid to reach and function the insert safety valve.

6.4.5.4 Investigation Run

Prior to, for example, rectifying a leak and/or subsurface safety valve issue, it is likely that an investigation tool will be deployed on slickline/wireline to better understand the issue. Typical examples would be:

- Run in Hole (RIH) and run an acoustic tool to detect the location of a potential tubing leak.
- RIH and run a downhole camera to obtain an imagine of the sub-surface safety valve internal condition.
- RIH and run a caliper or drift run to investigate any changes in well bore internal geometry.

6.4.5.5 Well Surveillance Well Entry

Although not envisaged it is possible that a slickline/wireline run is required for well surveillance purposes e.g.:

- RIH with an expandable gauge carrier to obtain downhole pressure and temperature in case the permanent downhole gauge is not functioning.
- RIH with a drift run to investigate a potential blockage below the completion tail pipe.

6.4.5.6 Well Production Reinstatement

In the unlikely event that sand production becomes an issue, there is the opportunity to run a slickline/wireline deployed sand screen hung off in the nipple profile located in the completion tail pipe.

6.4.5.7 Subsea Production Tree Change-out

There are a number of potential subsea production tree failure scenarios in the Well Failure Model (WFM) that could lead to a subsea production tree change out as a contingency operation. A high-level activity summary for a subsea production tree change out would typically be as follows:

1. Shut in well. Prior to tree cap removal the well shall be isolated from the well itself and from the production facility with two tested barriers.
2. Suspend well. This will involve installation of two independent well barriers. These can be either an inflow tested subsurface safety valve and a tested slickline/wireline deployed tubing hanger plug or two tested slickline/wireline deployed plugs. This can be executed by a vessel with Light Well Intervention capability similar to the LWI vessel used for the planned suspension plug recovery operation. As a result, Section 6.4.4.2 and all requirements and associated references are also applicable to contingency Light Well Intervention activities.
3. With isolations in place from the well and the production facility, depressurise the subsea production tree and well jumper and monitor for pressure build up.
4. Disconnect instrumentation and remove jumper lines. After jumper line removal install a high pressure suspension cap on the manifold as per ISO 13628-1 Part 15 (Design and operation of subsea production systems — Subsea Structures and Manifolds).
5. After closing and inflow testing the Annular Access Valve (AAV) recover subsea production tree to surface.
6. Install suspension cap on the tubing head and leave well suspended while repairing the subsea production tree (Acoustic Data Logger may be deployed for monitoring).
7. Post repair, recover suspension cap and install the subsea production tree.
8. With isolations in place from the production facility, recover the manifold suspension cap and install the jumper and instrumentation.
9. Pressure test the subsea production tree, well jumper and associated valves.
10. Recover well suspension plugs using a LWI vessel.

Risks which may result in a loss of well containment as a result of subsea production tree change out, e.g. dropped objects, are included in the Well Integrity Risk Registers.

6.4.6 Isolations from FLNG

With FLNG on location it is imperative that isolations are put in place during a Light Well Intervention to isolate the wells and the well intervention activities from the production facility and other wells. A number of FLNG Operating Procedures are in place to ensure adequate and tested isolations are in place. These isolations are critical in preparation for handover of the well from the asset to the wells team and vice versa at the start and end of the intervention activities. The specific procedures deal with:

- Prelude Subsea Isolation Strategy
- Lock-Out Tag-Out (LOTO) Manual
- Well Handover Procedure.

6.4.7 Crux Riser and Umbilical Tie-in

The Crux project is planned to take Final Investment Decision (FID) in mid-2020. The Crux 16” flexible riser and dynamic umbilical is planned to be installed on the Prelude FLNG facility around year 2023 with planned Crux RFSU in 2025.

Post riser and umbilical pull in to the Prelude FLNG, the subsea interface of the flexible riser and the umbilical are planned to be wet-parked in a designated laydown area (~10m x 10m) within the WA-44-L for up to 1 year.

The riser and dynamic umbilical will be leak tested after installation, with preservation fluid designed for up to 4 years. The wet-parked end fitting arrangement allows for the preservation fluid changeout via intervention vessel if required due to unforeseen changes to integration schedule.

Final make-up with the associated subsea structures is planned after the Crux export pipeline and subsea structures are installed in mid-2024. The wetparked riser and umbilical will be partially retrieved and installed onto the associated subsea structure interfacing with the Crux export pipeline (Figure 6-7).

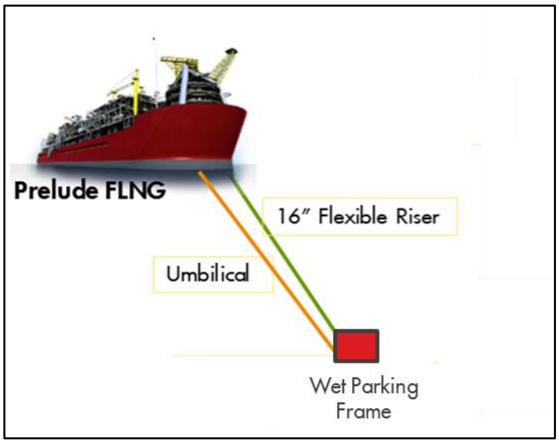


Figure 6-7: Crux Flexible Riser, Dynamic Umbilical, Wet Parking frame and Static Umbilical interface with the Prelude FLNG

6.5 Logistic Support Arrangement

6.5.1 Aviation Support Location

Prelude requires logistics support from the mainland of Australia. The primary means of mobilising personnel to the facility is by helicopter via Broome as the primary helicopter base. Djaradjin (also known as Lombadina) is used as a refuelling point to optimise operational efficiency dependant on environmental conditions. These helicopter bases may change in the future as company requirements may change. However, as the onshore bases are excluded from the scope of this EP, any change to the location of the base does not change the environmental risks from helicopter operations within WA-44-L.

6.5.2 Infield Support Vessel

The Infield Support Vessels (ISVs) support the operations of the Prelude FLNG facility, primarily fulfilling the role of Standby Vessels. Typically, two ISVs are present in the Prelude field area based on a rotation basis.

The ISVs perform the following roles and functions:

- Each ISV is provided with a Fast Rescue Craft (FRC) to facilitate rescue of persons from sea and where necessary the guiding of free floating life rafts.
- In a major emergency, the ISV acts as an emergency evacuation vessel.
- Acting as a place of safety or having the ability to transfer to an alternative vessel offshore or helicopter.
- Fire fighting with capability commensurate with notation Fi-Fi 1, with remote operated main water monitors and foam drenching system.
- Ability to provide Tier 1 oil spill response.
- 24/7 security surveillance for other vessels that might pose a threat to Prelude using existing systems (e.g. radar, floodlighting and other means of surveillance).
- Monitoring and maintaining traffic activities in the safety zone.
- Perform side by side berthing and unberthing operations for LNG and LPG Tankers.
- Perform tandem berthing and unberthing, hawser and hose handling operations of offtake Condensate tankers.
- Provide support during offloading of tankers.
- Enable transfer of FLNG TTLS (Pilots) and Service Technicians, Surveyors to the carriers and tankers upon arrival and return to FLNG on departure.
- Pilot transfer from the FLNG is primarily from the Preludes bow catcher located on Preludes Stern with secondary access being at the Port and Starboard doors.
- Perform environmental monitoring (or other similar vessel) if possible.

6.5.3 Supply Vessels

The Shell Marine Logistics Group supports the Prelude FLNG activities through the provision of the following contracted vessels including but not limited to:

- Platform Supply Vessel (PSV) (Figure 11) or Multi-purpose Platform Supply Vessel (MPSV)

- Anchor Handling Tug / Supply (AHTS)
- The scope of work for these dedicated vessels comprises of the following:
    - Port operations (Loading / discharging of cargo and specialist equipment)
    - The safe transportation of cargo / equipment to and from FLNG facility
    - Offshore Installation operations (Discharging / back-loading of cargoes and specialist equipment)
    - Anchor handling / towing operations (AHTS vessels only)
    - Infield emergency response support e.g. oil spill response, helicopter operations standby support.

Shell has contracted supply vessels that will support the Prelude activities. Up to four supply vessels are planned to be utilised during the installation and hook-up activities, and one supply vessel during normal operations. The MPSV can also be called to respond to subsea inspection and intervention requirements. The following is an example to contextualise/visualise.

6.5.4 Accommodation Support Vessels

Potentially during major maintenance activities or shutdowns, an accommodation support vessel (ASV) may be necessary to provide accommodations for additional personnel in excess of the FLNG's capacity.

7.0 Description of the Receiving Environment

As required by regulations 13(2) and 13(3) of the OPGGS(E) Regulations, a description of the receiving environment that may be affected by the activities (both planned and unplanned) covered by this EP is provided in this section. The information contained in this section has been used to inform the assessment of environmental impacts and risks presented in Section 9.3 to Section 9.14.

The spatial extent of the receiving environment encompasses the physical, biological and socio-economic receptors that may be affected by planned and unplanned activities. The majority of the impacts and risks from the activities covered by this EP occur in close proximity to the Prelude FLNG facility (i.e. within the Operational Area around the facility and associated infrastructure), however some impacts and risks may extend further. The credible worst-case hydrocarbon release scenarios determined by modelling studies are predicted to present the greatest spatial extent of all the impacts and risks identified. The outer boundary of the area that may be influenced by the petroleum activities, identified by the modelling and referred to as the Zone of Potential Influence (ZPI), has been used as the outer boundary for the description of the receiving environment. The worst-case hydrocarbon releases during operations have a remote to extremely remote likelihood of occuring, and Shell implements a range of controls to ensure such incidents are prevented, and mitigated to ALARP and Acceptable Levels. The ZPI for the combined worst-case credible hydrocarbon spills from the Prelude FLNG facility and associated petroleum activities is shown in Figure 7-1 and this represents the low exposure thresholds described further in Table 9-67. Refer to Section 9.13 for additional information on hydrocarbon spill modelling and risk management and associated impact thresholds applied for the assessment.

The description of the receiving environment considers environmental receptors that are protected under the EPBC Act, including:

- World heritage and national heritage values
- Ramsar wetlands
- listed threatened species, migratory species and threatened ecological communities
- values and sensitivities within the Commonwealth marine environment.

The EPBC Act Protected Matters Search Tool (PMST) was used to identify environmental receptors protected under the Act. Two EPBC Act PMST reports were generated; one based on the Operational Area and one based on the combined entrained, dissolved and surface ZPI. PMST Reports for both the Operational Area and ZPI are provided in Appendix 13.0.

Figure 7-1: ZPI for the Prelude FLNG facility and associated Petroleum Activities

7.1 Physical Environment

7.1.1 Seabed

The Operational Area is located in the Timor Sea on the outer continental slope between 200 and 300 m depth. The seabed within the Operational Area, and within the WA-44-L permit more broadly, is relatively flat and featureless. Baseline environmental study results for the Prelude development show the seabed is characterised by unconsolidated sand, silt and mud (Shell 2009). No reefs or extensive areas of rocky substrate have been observed.

Notable seabed features in the ZPI beyond the Operational Area include the coral reefs and islands that occur throughout the region. The closest of these features, Browse Island, is located some 40 km south-southeast of Prelude. There are also numerous reefs, banks and shoals throughout the Timor Sea, which host diverse biological communities. Other notable seabed features in the ZPI include Ashore Reef, Cartier Island, Scott Reef, the Rowley Shoals, and numerous reefs, banks and islands off the Kimberley and Pilbara coasts. Refer to Section 7.2 for further discussion of the biological communities associated with these seabed features.

7.1.2 Climate

Prelude is situated in the tropics and experiences a monsoonal climate with two seasons. The Australian northern monsoon generally occurs between December and March (Figure 7-2). It is associated with the inflow of moist west to north-westerly winds into the monsoon trough, producing convective cloud and heavy rainfall over northern Australia. During the cooler months (June - September), the sub-tropical ridge that lies over continental Australia drives stable and persistent easterly winds over the region. The Australian cyclone season officially runs from November to April, although very few storms have occurred in November. The chance of experiencing an intense category 4 or 5 cyclone is highest in March and April. At the start of the cyclone season, the most likely area to be affected is the Kimberley and Pilbara coastline and offshore areas including the Operational Area, with the area threatened later in the season extending further south.

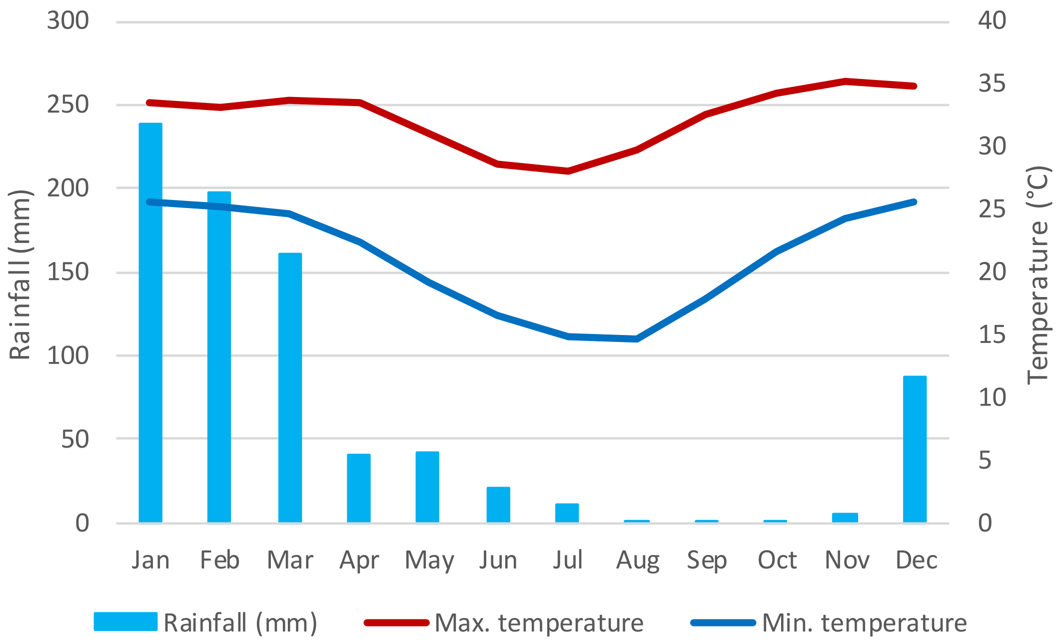


Figure 7-2: Long-term maximum and minimum temperatures and mean rainfall from Cygnet Bay (closest Bureau of Meteorology climate station to Prelude FLNG). Data sourced from Bureau of Meteorology (n.d.)

7.1.3 Oceanography

The regional currents influencing the offshore waters off northern and western Australia are shown in Figure 7-3. The majority of water movement off northern Western Australia is poleward, with the water being relatively warm and low in nutrients (Department of the Environment, Water, Heritage and the Arts (DEWHA) 2008). A strong seasonal wind regime is closely associated with seasonality in surface currents in the region, including the seasonal strength of trade winds in the equatorial Pacific Ocean which drive the Indonesian Throughflow (ITF).

The project is located within the North West Marine Region (NWMR)[2] which experiences semi-diurnal tides. Tidal ranges are large - 0.8 m neaps and 5 m springs (RPS 2018) - and strongly influence currents in the region. Notably, tidal amplitudes seem to be retained at large distances offshore and travel initially in a north-east direction in the deeper waters of the region (RPS 2018). The tidal current component is imposed over the synoptic-scale flow.

In addition to synoptic-scale and tidal currents, locally generated wind-driven currents also influence water movement within the Operational Area and ZPI. These are more variable and are superimposed over large-scale flows.

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[2] A series of bioregional plans have been developed by the Commonwealth government. These plans are intended to help improve the way decisions are made under the EPBC Act. The Operational Area (and much of the ZPI) overlaps the area convered in the Marine bioregional plan for the North-west Marine Region: prepared under the Environment Protection and Biodiversity Conservation Act 1999 (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012a); hence the Operational Area is within the NWMR.

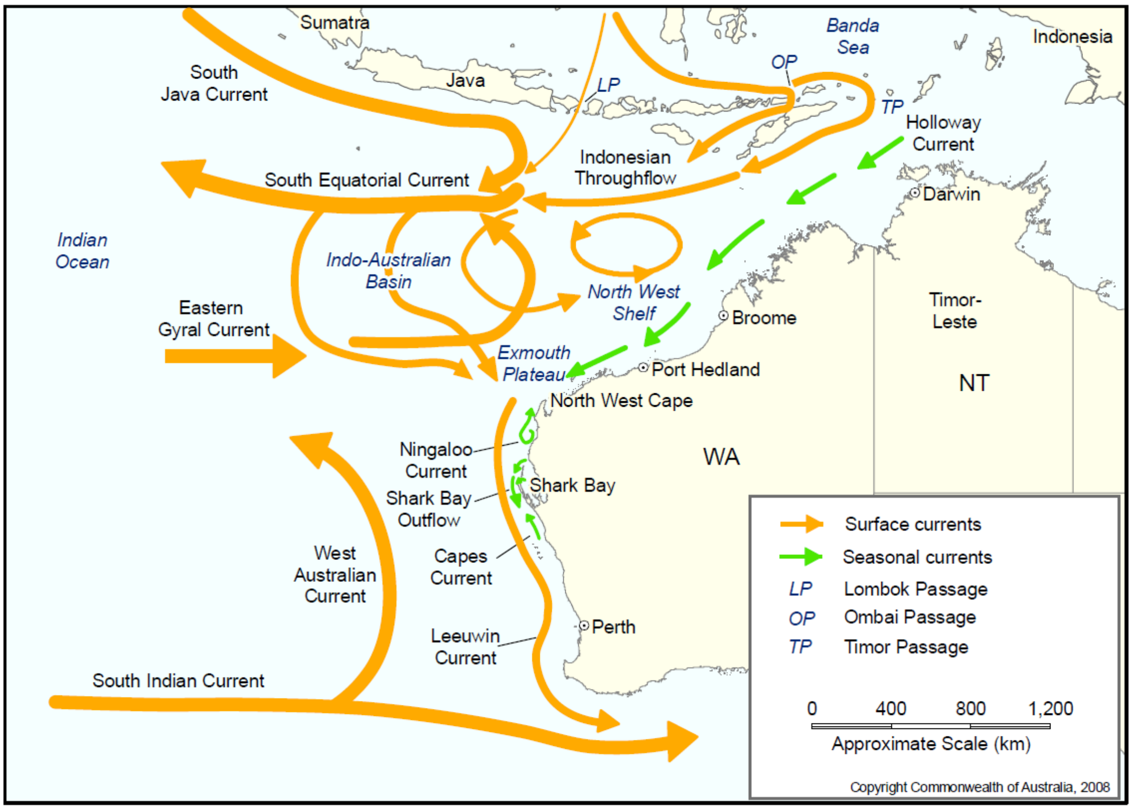

Figure 7-3: Regional synoptic-scale currents off north-western Australia (from DEWHA 2008)

7.1.4 Water Quality

Water quality in the vicinity of Prelude is generally high. Results from baseline water quality surveys in support of the Prelude EIS indicated potential contaminants, such as metals and hydrocarbons, were low and often below the laboratory limits of detection (Shell 2009). These results are consistent with other survey results in the Timor Sea (Ross et al. 2017). Nutrient and turbidity levels in the water column were also low compared to nearshore waters, which is typical for offshore waters and is consistent with other surveys in the region (Ross et al. 2017). The average salinity for the receiving water is approximately 34.5ppt (ERM 2008).

Water quality in the immediate vicinity of the Prelude FLNG facility is slightly lower due to routine discharges from the facility (e.g. grey water, sewage, PFW etc.). The area impacted by these discharge streams is localised; refer to Section 9.9 for further information.

7.1.5 Sediment Quality

Sediments at Prelude are described as very soft carbonate silts to a depth of about 10m below the seabed. Baseline studies showed concentrations of potential contaminants, such as hydrocarbons and metals, were typically low and similar to other studies in the region (Ross et al. 2017, Shell 2009).

Installation of subsea facilities (e.g. wells, xmas trees, flowlines and umbilicals) resulted in isolated areas of sediment disturbance. Higher concentrations of potential contaminants from drill cuttings and fluids, such as barite, may occur in the cuttings piles from historical drilling activities. These areas are expected to be highly localised (i.e. within 100's of metres from wellheads).

7.1.6 Air Quality

No specific information concerning air quality in the local airshed area is available. However, the Operational Area is approximately 200 km from the Kimberley coastline, which itself is a remote and unindustrialised area. Therefore, the air quality is unlikely to be subject to considerable anthropogenic effects with the exception of the Prelude FLNG facility. Emissions from commercial shipping are likely to represent the main source of localised and temporary impacts on air quality. Production facilities in the broader region, such as the Montara FPSO facility (approximately 188 km from the Operational Area), the Ichthys FPSO (approximately 17 km from the Operational Area) and the future Shell Crux normally not manned platform (165 km from the Operational Area), are also expected to incrementally influence local and regional air quality.

In a regional context, the main contributors to particulate levels are ambient wind-borne dust and smoke from seasonal bush fires that are characteristic across the Kimberley regions. International contributors to reduced air quality in the project area may also include the likes of 'slash-and-burn' agricultural methods and other large forest fires in South-East Asian countries (Vadrevu et al. 2014; Kim Oanh et al. 2018).

7.1.7 Underwater Noise

The baseline underwater noise monitoring program in support of the Prelude EIS recorded the following natural and anthropogenic features of:

- several regular fish choruses (i.e. schooling fish calling en masse)
- several great whale calls including humpback whales, pygmy blue whales in late October 2006 and possible minke whale calls
- persistent vessel noise
- seismic survey noise associated with marine seismic survey signals.

The biological noise sources recorded in the nearby Ichthys field were similar and included regular fish choruses, infrequent calls from nearby fish and several whale calls from humpback whales, pygmy blue whales, minke whales and other unidentifiable species (INPEX Browse 2010). Anthropogenic noise sources recorded included low frequency noise from vessels and that generated from seismic surveys being conducted in the region (INPEX Browse 2010).

7.2 Biological Environment

7.2.1 Benthic Communities

7.2.1.1 Bare Sediment

Surveys of benthic habitats within the Operational Area showed low density epibenthic communities of deposit and filter feeders on bare sediments, which is typical of this habitat in the region (Baker et al. 2008). Infauna were dominated by polychaete worms, which accounted for approximately 80% of individual infauna sampled (Shell 2009). This finding is consistent with other studies across the region, which showed infauna communities in similar water depths are dominated by polychaetes and crustaceans (Heyward et al. 1997). Given the water depth within the Operational Area, no benthic primary producers will occur due to the lack of photosynthetically active radiation reaching the seabed.

Bare sediment habitats are also the most common habitat type within the ZPI, although there are discrete areas of other benthic habitat types associated with features such as islands and shoals, such as corals, macroalgae, seagrasses and mangroves (discussed below).

7.2.1.2 Corals

While hard (zooxanthellate) corals are not present within the Operational Area, they are widespread throughout the ZPI in relatively shallow (< 50 m) waters. Much of the open water environment in the ZPI is too deep for growth of hard corals, and coral communities are typically associated with the named islands, shoals, reefs and banks throughout the ZPI, including:

- Browse Island (approximately 39 km from the Operational Area)
- Echuca Shoal (approximately 61 km from the Operational Area)
- Heywood Shoal (approximately 81 km from the Operational Area)
- Cartier Islet (approximately 136 km from the Operational Area)
- Seringapatam Reef (approximately 136 km from the Operational Area)
- Goeree Shoal (approximately 144 km from the Operational Area)
- Vulcan Shoal (approximately 146 km from the Operational Area)
- Scott Reef (approximately 159 km from the Operational Area)
- Ashmore Reef (approximately 169 km from the Operational Area)
- Hibernia Reef (approximately 194 km from the Operational Area).

Coals reef communities are also widespread along the coastlines of Indonesia and Timor-Leste, including:

- Rote Island (approximately 322 km from the Operational Area)
- Timor (approximately 381 km from the Operational Area)
- Sawu Island (approximately 388km from the Operational Area
- Sumba (approximately 494 km from the Operational Area).

Corals, particularly reef-forming corals, form an important component of benthic communities by providing habitat. In turn, this habitat supports relatively diverse associated communities, such as fish assemblages and macroalgal communities. Coral rubble from dead hard coral colonies also results in in situ sediment production, which may be an important source of biogenic sediments at banks and shoals in the Timor Sea (Heyward et al. 2012).

Corals in the region are thought to spawn seasonally, with two distinct mass spawning events in autumn and spring observed (Gilmour et al. 2009, Rosser and Gilmour 2008). This contrasts with other coral reef communities in the Indo-Pacific, such as the Great Barrier Reef and Ningaloo Reef, which typically exhibit a single annual mass spawning event. Coral reefs in the Timor Sea exhibit recruitment from both local (i.e. self-seeding) and distant (e.g. reefs located 10’s to 100’s of kilometres away) propagules

(Gilmour et al. 2013). This has implications for the recovery of coral reefs following disturbance, such as bleaching events or cyclones.

7.2.1.3 Macroalgae & Seagrasses

Like corals, much of the ZPI does not receive sufficient photosynthetically active radiation at the seabed to support macroalgae and seagrass communities. The areas that do are typically associated with physical features such as reefs, banks, shoals, islands and the mainland coasts of Australia, Indonesia and Timor-Leste. Macroalgae and seagrass communities in these areas provide relatively complex habitat structure that supports greater species richness and diversity. Primary productivity from these communities also supports food webs through direct grazing and consumption of detritus.

Macroalgae are an important feature in the seabed communities at several offshore banks and shoals in the ZPI, particularly calcareous green algae in the genus *Halimeda*. Geological coring studies of several Timor Sea banks and shoals indicates extensive deposition of carbonate sediments from *Halimeda* spp. (Heyward et al. 1997), which may account for the creation and maintenance of these geological structures near the sea surface. Seagrasses at banks and shoals tends to be less common and more ephemeral than macroalgae, with surveys showing considerable temporal variability at the scale of years (Heyward et al. 2012).

7.2.1.4 Mangroves

Mangroves are widely distributed along the coastlines within the ZPI, including Indonesia (Timor and Sumba), the Pilbara and the Kimberley coastline. Mangroves habitats are of environmental value due to the shoreline stabilisation and habitat they provide. Many fauna species either complete their life cycles within mangrove habitats, or utilise mangroves during particular life history stages (e.g. nursery habitat for juveniles (Robertson and Duke 1987). The nearest potential mangrove habitat to the Operational Area are the islands and mainland coast of the Kimberley region, over 200 km from the Prelude LNG facility.

7.2.2 Pelagic Communities

7.2.2.1 Plankton

Plankton are organisms, typically small in size, whose movements are determined largely by currents rather than active movement (e.g. swimming). Plankton communities are often categorised into two groups: phytoplankton (drifting plants) and zooplankton (drifting animals).

Surveys in the Operational Area found phytoplankton communities to be highly diverse but low in abundance. Key groups identified include dinoflagellates (Dinophyceae), diatoms (Bacillariophyceae) and Prasinophyceae. The most abundant species included *Prasinophyte* sp. (Prasinophyceae); *Gyrodinium* sp. and *Heterocapsa* sp. (Dinophyceae); *Pseudonitzschia* sp., *Cylindrotheca closterium*, *Chaetoceros* sp., *Thalassionemafrauenfeldii* and *Nitzschia longissima* (Bacillariophyceae) (Shell 2009). Phytoplankton in the wider region is similar to that observed in the project area with relatively high diversity in certain groups recorded such as diatoms, dinoflagellates and coccolithophorids (Hallegraeff and Jeffrey 1984).

Zooplankton samples collected in July 2008 found crustacean assemblages to be primarily dominated by copepod species (Shell 2009). Overall densities of zooplankton assemblages were relatively low and typical of low nutrient open ocean environments in the region. A few samples were dominated by euphausiids or chaetognaths (Shell 2009).

Some fauna groups, such as fish and crustacean species, often have a planktonic larval stage following which they assume a free-swimming or benthic existence. The larval fish community within the Operational Area was relatively diverse and abundant; however, species composition was primarily dominated by neritic species, which have little or no commercial value (Shell 2009). Commercial species identified came from groups typical of a range of marine habitats including pelagic shelf systems and both coastal and deep sea demersal habitats. Larvae were identified from the following groups which have commercially targeted species: Berycidae, Carangidae (trevally and jacks), Lutjanidae (tropical snappers), Serranidae (cods), and Scombridae (mackerels and tunas).

7.2.2.2 Pelagic Fish & Invertebrates

Free swimming pelagic fauna within the Operational Area and ZPI are expected to include pelagic fishes, marine turtles, seasnakes, squid, and cetaceans. Several of these fauna groups (e.g. whale sharks, several cetacean species, marine turtles) are listed threatened and / or migratory under the EPBC Act; these species are considered in Section 7.2.4 Threatened Ecological Communities.

Small pelagic fishes, such as sardines and anchovies, form an important trophic link between microscopic planktonic communities (e.g. zooplankton feeding on phytoplankton) and larger consumers (e.g. tunas). Small pelagic fishes are expected to be broadly distributed throughout the tropical pelagic environment given the relatively homogeneous nature of the open sea, with food availability and predation also influencing the distribution and abundance of these species.

The distribution of larger pelagic fishes (e.g. tunas, bonito, blue sharks etc.) are expected to mirror the distribution of small pelagic fishes, as small pelagic fishes are the primary prey of these larger species. Several pelagic fish species, such as marlin, swordfish and mackerel, are important for commercial and recreational fisheries, although fishing effort in the Operational Area and much of the ZPI is very low. The commercially important southern bluefin tuna is thought to spawn in the north-eastern Indian Ocean, although this species is not fished within the Operational Area or ZPI.

7.2.3 Key Ecological Features

Key Ecological Features (KEFs) are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region’s biodiversity or its ecosystem function and integrity. There are no KEFs present within the Operational Area; several KEFs have been identified within the ZPI. A summary of the KEFs overlapped by the ZPI are shown in Figure 7-4 and listed in Table 7-1.

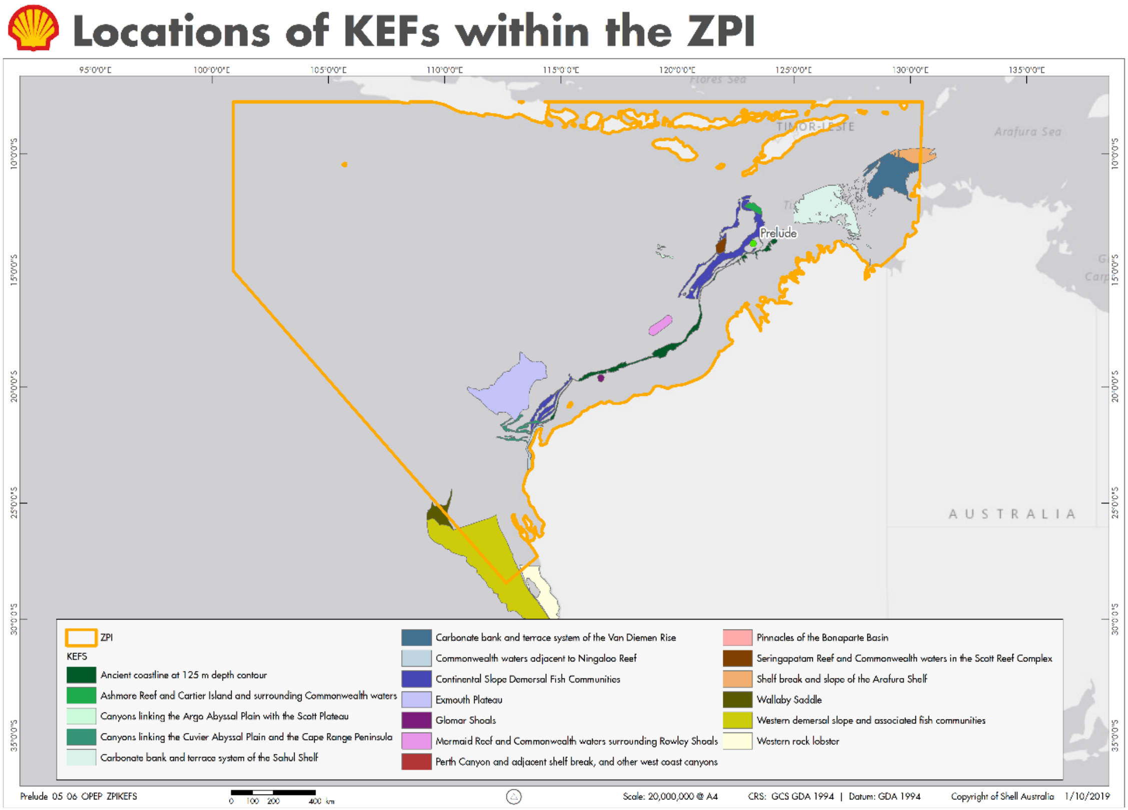

Figure 7-4: Locations of KEFs within the ZPI

Table 7-1: Descriptions of KEFs within the ZPI, including distance from Prelude FLNG

KEF	Distance from Prelude (km)	Description
Continental Slope Demersal Fish Communities	14	***Communities with high species biodiversity and endemism*** There is a high diversity of demersal fish assemblages on the Australian continental slope from the North West Cape to the edge of the NMR. The continental slope between North West Cape and the Montebello Trough has more than 500 fish species, 76 of which are endemic, which makes it the most diverse slope bioregion in the whole of Australia. The KEF covers a vast area of approximately 33,182 km^2.
Ancient coastline at 125 m depth contour	41	***Unique seafloor feature with ecological properties of regional significance*** The areas of hard substrate along this ancient coastline, which follows the 125 m depth contour, are thought to provide biologically important habitats in areas otherwise dominated by soft sediments; thereby providing for higher species diversity and richness relative to the wider region. The topographic complexity of these escarpments may also facilitate vertical mixing of the water column providing a relatively nutrient-rich environment for species present on the

		escarpment. The KEF encompasses an area of approximately 16,190 km^2.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	131	***High productivity and aggregations of marine life*** The coral communities at Seringapatam and Scott Reefs play a key role in maintaining species richness and aggregations of marine life. The reefs and the waters surrounding them attract aggregations of marine life including migratory cetaceans. Green and hawksbill turtles nest during the summer months on Sandy Islet on South Scott Reef. These species also inter-nest and forage in the surrounding waters. Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species, around 720 fish species and several species of sea snakes.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	134	***High productivity and aggregations of marine life*** Ashmore Reef is the largest of only three emergent oceanic reefs present within the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. The emergent reefs are known to provide areas of enhanced primary productivity in otherwise oligotrophic environments. Ashmore Reef and Cartier Islands and the surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of seabirds and shorebirds, and other marine life. Ashmore Reef regularly supports more than 40,000 waterbirds (those ecologically dependent on wetlands) and is estimated to support as many as 100,000 seabirds in a twelve month period (Hale and Butcher 2013). The marine habitats supported by the reefs are nationally and internationally significant, providing habitat for diverse and abundant marine reptile (including feeding, nesting and inter-nesting areas for green, hawksbill and loggerhead turtles) and marine mammal populations, including dugongs. Species at Ashmore and Cartier include more than 225 reef-building corals, 433 molluscs, 286 crustaceans, 192 echinoderms, and 709 species of fish. Thirteen species of sea snakes occur in high numbers at Ashmore and Cartier reefs but are thought to be in decline (Threatened Species Scientific Committee 2010a).
Carbonate bank and terrace system of the Sahul Shelf	206	***Unique seafloor feature with ecological properties of regional significance*** While little is known about this KEF, the carbonate banks and terrace system of the Sahul Shelf is considered regionally important because of their role in enhancing biodiversity and local productivity relative to their surrounds, largely due to the presence of elevated hard substrates. The seabed features are thought to create enhanced productivity and biodiversity as a result of upwellings of cold nutrient-rich water at the heads of the channels. The KEF covers an area of approximately 41,158 km^2. The banks rise to depths of 150 m – 300 m and are separated from each other by narrow meandering channels which are up to 150 m deep. The hard substrates of the banks are thought to support a high diversity of benthic organisms.
Canyons linking the Argo Abyssal Plain with the Scott Plateau	384	***High productivity and aggregations of marine life*** Canyons linking the Argo Abyssal Plain with Scott Plateau covers an area of approximately 836 km^2. The Bowers and Oats canyons are major canyons on the slope between the Argo Abyssal Plain and Scott Plateau and deeply cut into the Scott Plateau at depths of approximately 2,000 m – 3,000 m. The ocean area above the canyons is thought to be an area of moderately enhanced

		productivity, attracting aggregations of fish, sharks, toothed whales and dolphins.
Pinnacles of the Bonaparte Basin	457	***Unique seafloor feature with ecological properties of regional significance*** The limestone pinnacles in the western Bonaparte Depression are expected to support a diverse community in an otherwise oligotrophic system. More than 110 pinnacles occur in the Bonaparte Depression, covering a total area of more than 520 km^2. The pinnacles are thought to be the eroded remnants of underlying strata and can be up to 50 m high and 50 km–100 km long.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	523	***High productivity and aggregations of marine life*** The Rowley Shoals consist of three atoll reefs, Clerke, Imperieuse and Mermaid Reef, which support 214 coral species and around 530 species of fish. The steep changes in slope around the reef also attract a range of migratory pelagic species such as dolphins, tuna, billfish and sharks. The coral communities of Mermaid Reef are also an important feature. The enhanced productivity at the shoals is thought to be facilitated by the breaking of internal waves in the waters surrounding the reefs, causing mixing and re-suspension of nutrients from water depths of 500 – 700 m into the photic zone.
Glomar Shoals	941	***High productivity and aggregations of marine life*** The Glomar Shoals (approximately 786 km^2) are a submerged littoral feature located approximately 150 km north of Dampier on the Rowley shelf at depths of 33 m – 77 m. While biological data is limited, the fish of Glomar Shoals are believed to be a subset of reef-dependent species. The shoals are known to be an important area for a number of commercial and recreational fish species such as Rankin cod, brown-striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish.
Exmouth Plateau	1,127	***Unique seafloor feature with ecological properties of regional significance*** The Exmouth Plateau is a large, mid-slope, continental margin plateau that ranges in depth from approximately 800 to 3,500 m. The Exmouth Plateau is overlaid by an interface between the ITF and the Indian Ocean Central Water. This interface constitutes a potential shear zone (with associated mixing). The seascape of the Exmouth Plateau is not considered to be unique by Falkner et al. (2009) in their review of KEFs in the northwest marine region, however the geological origin and potential enhanced upwelling due to the Exmouth Plateau may constitute unique environmental values (DSEWPaC 2012a).
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	1,256	***Unique seafloor feature with ecological properties of regional significance*** The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF lies off the north-west coast of Australia. Interactions with the Leeuwin current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al. 2007). Note that such upwelling may not result from the presence of the canyons, but from other factors such as local wind stress (e.g. upwelling off the Capes region in south-western Australia) and internal waves (Taylor and Pearce 1999, Woo et al. 2006).
Commonwealth waters adjacent to Ningaloo Reef	1,304	***High productivity and aggregations of marine life*** Ningaloo reef is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent. It is also globally significant as a seasonal aggregation site for whale sharks. The

		Commonwealth waters adjacent to Ningaloo Reef and associated canyons and plateau are interconnected and support the high productivity and species richness of Ningaloo Reef. The Leeuwin and Ningaloo currents interact on the seaward side of the reef, leading to areas of enhanced productivity (DoEE n.d.).
Demersal slope and associated fish communities of the Central Western Province	1,747	***High levels of biodiversity and endemism*** The Demersal slope and associated fish communities of the Central Western Province provides important habitat for demersal fish communities. In particular, the continental slope of the Central Western provincial bioregion supports demersal fish communities characterised by high diversity compared with other, more intensively sampled, oceanic regions of the world. Its diversity is attributed to the overlap of ancient and extensive Indo-west Pacific and temperate Australasian fauna (Williams et al. 2001).
Western rock lobster	1,862	***Ecological role on the west coast continental shelf*** The Western rock lobster KEF covers a considerable portion (~40,000 km^2) of continental shelf waters on the lower west coast of Western Australia and was established in recognition of the presumed ecological role played by the western rock lobster (*Panulirus cygnus*) in shelf waters (DSEWPaC 2012b).
Wallaby Saddle	1,898	***High productivity and aggregations of marine life*** The Wallaby Saddle is located in water depths ranging from 4,000 to 4,700 m. The Wallaby Saddle is an abyssal geomorphic feature linking the north-west margin of the Wallaby Plateau with the upper continental slope margin of the Carnarvon Basin.
Perth Canyon and adjacent shelf break, and other west coast canyons	1,934	***Higher productivity that attracts feeding aggregations of deep-diving mammals and large predatory fish*** The Perth Canyon is the largest canyon on the Australian margin and, together with numerous smaller submarine canyons that incise the continental slope of southern Western Australia, is expected to have high biodiversity values. The west-coast canyons are believed to be associated with small periodic upwellings that locally increase productivity and attract aggregations of marine life. In the Perth Canyon, interactions between the canyon topography and the Leeuwin Current induce clockwise-rotating eddies that transport nutrients upwards in the water column from greater depths. Due to the canyon's depth and the Leeuwin Current's barrier effect, this remains a subsurface upwelling (depths greater than 400 m), which confers ecological complexity that is typically absent from canyon systems in other areas (Pattiaratchi 2007).

7.2.4 Threatened Ecological Communities

Threatened Ecological Communities (TECs) are protected under Part 3 of the EPBC Act and are MNES. The PMST report for the ZPI indicated that the monsoon vine thickets on the coastal sand dunes of the Dampier Peninsula TEC lies within the ZPI, approximately 285 km from the Operational Area at the closest point.

The identification of this TEC by the PMST report is an artefact of the method used to derive the search area for the PMST. This TEC lies entirely above the high water mark and will not credibly be impacted by a worst-case hydrocarbon spill. Hence, this TEC is not considered further in this EP.

No other TECs were identified that may credibly be affected by the petroleum activities considered in this EP.

7.2.5 Ramsar Wetlands

Sites recognised under the Convention on Wetlands of International Importance (the Ramsar Convention), referred to as Ramsar wetlands, are protected under Part 3 of the EPBC Act and are MNES. Several Ramsar wetlands were identified within the ZPI; the environmental values for these Ramsar wetlands are shown in Figure 7-5 and summarised in Table 7-2.

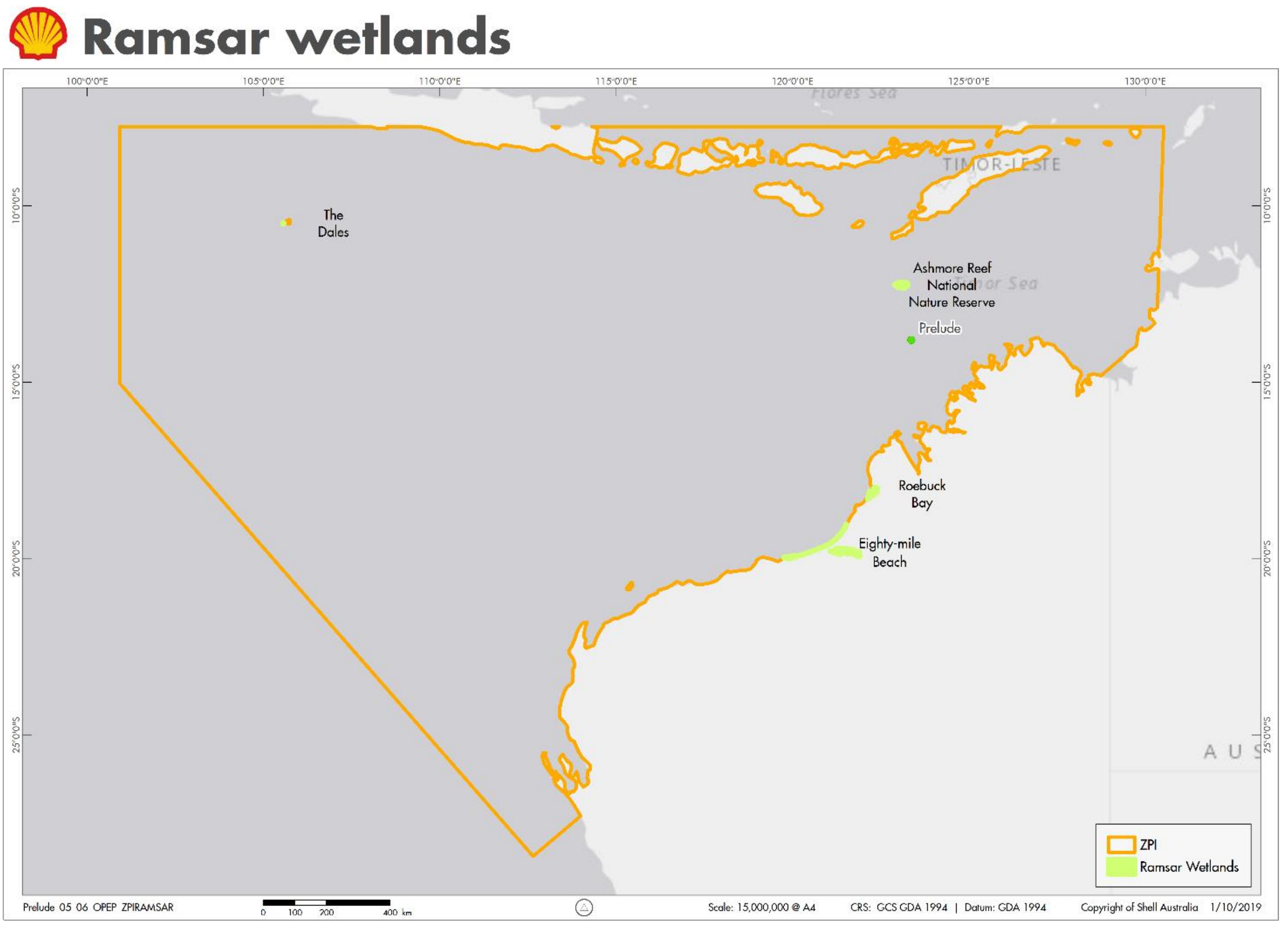

Figure 7-5: Ramsar Wetlands within the ZPI

Table 7-2: Descriptions of Ramsar Wetlands within the ZPI, including distance from Prelude FLNG

Ramsar Wetland	Distance from Prelude (km)	Description
Ashmore reef national nature reserve	162	Ashmore Reef supports an abundance and diversity of birds; 72 species have been recorded at this Ramsar site, with 12 recorded breeding (Hale and Butcher 2013). Ashmore Reef was designated as a Ramsar wetland based on the following characteristics:

		• Ashmore is the largest of the atolls in the region and has been managed for the purposes of conservation for three decades. • Each of the wetland types is in near natural condition, with low densities of coral predators and disease. • The three islands represent the only vegetated island within the Timor Province bioregion. • It supports 64 threatened species. • It is considered a true 'hotspot' of biological diversity within the Timor Province bioregion and within the broader north-west marine region. • It supports 47 species of waterbird listed as migratory under international treaties and three species of migratory turtle (green, hawksbill and loggerhead). It also supports breeding of green and hawksbill turtles, dugongs and 20 species of waterbird. • It regularly supports over 40,000 waterbirds including large numbers of migratory shorebirds and breeding seabirds (Hale and Butcher 2013). Ashmore Reef is also recognised as a KEF and is within the Ashmore Reef Australian Marine Park (AMP) (refer to 7.2.3).
Roebuck bay	474	The Roebuck Bay Ramsar site is located at Roebuck Bay near Broome in north Western Australia. Roebuck Bay has a very large tidal range which exposes around 160 square kilometres of mudflat, covering most of the Ramsar site. The eastern edge of the site is made up of microscale linear tidal creeks. The intertidal mud and sand flats support a high abundance of bottom dwelling invertebrates, which are a key food source for waterbirds. The site is one of the most important migration stopover areas for shorebirds in Australia and globally. For many shorebirds, Roebuck Bay is the first Australian landfall they reach on the East Asian Australasian Flyway. The total numbers of waders using the site each year is estimated at over 300 000. The northern beaches and Bush Point provide important high tide roost sites.
Eighty-mile beach	610	Eighty-mile Beach Ramsar site, located between Port Hedland and Broome in north Western Australia, is made up of Eighty-mile Beach and, 40 km to the east, Mandora Salt Marsh. Eighty-mile Beach is a 220 km section of coastline and adjacent intertidal mudflats. Eighty-mile Beach is characterised by extensive mudflats supporting an abundance of macroinvertebrates which provide food for large numbers of shorebirds. More than 472,000 migratory waders have been counted on the mudflats during the September to November period. The site is considered to be one of the major arrival and departure areas for migratory shorebirds visiting Australia, particularly on southward migration. It is one of the most important sites in the world for the migration of the Great Knot.
The dales	1,994	The Ramsar site has a near-pristine system of seven watercourses collectively known as The Dales. The Dales includes permanent and perennial streams, permanent springs, and include the majority of surface water on the Island. Most rainfall on Christmas Island filters down through the soil and limestone, and surface runoff only occurs after heavy rain. The Dales contain numerous wetland types including surface and karst features, and inland and coastal wetlands. The Dales support a number of unique ecological and geomorphic features including anchialine cave communities, surface karst including the unique stepped tufa deposits at Hugh's waterfall, a

		stand of Tahitian chestnuts, a large number of endemic terrestrial species and a significant number of seabirds including Abbott's booby, red-footed booby and the brown booby, all of which breed at the site.

7.2.6 Commonwealth Marine Area

The Operational Area is located within the Commonwealth marine area, which includes any part of the sea, including the waters, seabed and airspace, within Australia’s exclusive economic zone and/or over the continental shelf of Australia, that is not state or NT waters. The Commonwealth marine area stretches from three to 200 nm from the coast.

7.2.7 WA Mainland Coastline

The WA mainland coastline lies over 200 km from the Prelude FLNG at the closest point, with several parts of the Kimberley and Pilbara coastlines within the outer edge of the ZPI. These coastlines support a diverse array of coastal and nearshore marine habitats including coral reefs, sandy beaches, rocky shores, seagrass meadows, mangroves, wetlands, estuaries, creeks and rivers. These environments in turn support a number of fauna, including EPBC listed seabirds and migratory shorebirds, turtles, sea snakes, dugongs, cetaceans, fish, sharks and rays (refer to Section 7.2.8).

The WA nearshore and coastal areas provide Indigenous and European heritage value, as well as cultural, social and economic values such as local tourism and recreation (refer to Section 7.3). The nearshore and coastal habitats also support a number of culturally and commercially significant marine fauna species such as marine turtles, dugongs, fish and prawns.

7.2.8 Threatened and Migratory Species

A total of 102 EPBC Act listed species considered to be MNES (46 and 91 listed as threatened or migratory respectively) were identified as potentially occurring within the ZPI, of which a subset of 34 were identified as potentially occurring within the Operational Area (Table 7-3). The full list of marine species identified from the protected matters search is provided in Appendix B: EPBC Act Protected Matters Reports.

Note that a number of MNES that will not credibly be impacted by the petroleum activities considered were identified by the PMST Report for the ZPI (e.g. terrestrial species within the wider ZPI). These PMST report results are an artefact of the method used to generate the area upon which the report is based; this method occasionally overlaps small areas of the terrestrial environment that will not credibly be impacted by the petroleum activity. These have been excluded from further consideration and are not listed in Table 7 3; justifications for these exclusions are provided in Appendix B: EPBC Act Protected Matters Reports.

Table 7-3: EPBC Act listed threatened and migratory fauna potentially occurring within the Operational Area and ZPI identified by the PMST reports that may credibly be impacted by the petroleum activities considered in this EP

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area / ZPI
Mammals				
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	Operational Area
Balaenoptera edeni	Bryde's whale	N/A	Migratory	
Balaenoptera musculus	Blue whale	Endangered	Migratory	
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	
Orcinus orca	Killer whale, orca	N/A	Migratory	
Physeter macrocephalus	Sperm whale	N/A	Migratory	
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/Timor Sea populations)	N/A	Migratory	
Balaenoptera bonaerensis	Antarctic Minke Whale, Dark-shoulder Minke Whale	N/A	Migratory	ZPI
Dugong dugon	Dugong	N/A	Migratory	
Eubalaena australis	Southern Right Whale	Endangered	Migratory	
Orcaella heinsohni	Australian snubfin dolphin	N/A	Migratory	
Sousa chinensis (sahulensis)	Indo-Pacific (Australian) humpback dolphin	N/A	Migratory	
Reptiles				
Caretta	Loggerhead turtle	Endangered	Migratory	Operational Area
Chelonia mydas	Green turtle	Vulnerable	Migratory	
Dermochelys coriacea	Leatherback turtle, leathery turtle, luth turtle	Endangered	Migratory	
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	
Lepidochelys olivacea	Olive ridley turtle, pacific ridley turtle	Endangered	Migratory	
Natator depressus	Flatback turtle	Vulnerable	Migratory	
Aipysurus apraefrontalis	Short-nosed seasnake	Critically endangered	N/A	ZPI

Aipysurus foliosquama	Leaf-scaled seasnake	Critically endangered	N/A	
Crocodylus porosus	Salt-water crocodile, estuarine crocodile	N/A	Migratory	
Sharks and Rays				
Anoxypristis cuspidata	Narrow sawfish, knifetooth sawfish	N/A	Migratory	Operational Area
Carcharodon carcharias	White shark, great white shark	Vulnerable	Migratory	
Glyphis garricki	Northern river shark, New Guinea river shark	Endangered	N/A	
Isurus oxyrinchus	Shortfin mako, mako shark	N/A	Migratory	
Isurus paucus	Longfin mako	N/A	Migratory	
Manta birostris	Giant manta ray, chevron manta ray, Pacific manta ray, pelagic manta ray, oceanic manta ray	N/A	Migratory	
Pristis zijsron	Green sawfish, dindagubba, narrowsnout sawfish	Vulnerable	Migratory	
Rhincodon typus	Whale shark	Vulnerable	Migratory	
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)	Vulnerable	N/A	ZPI
Lamna nasus	Porbeagle, Mackerel Shark	N/A	Migratory	
Manta alfredi	Reef manta ray, coastal manta ray, inshore manta ray, Prince Alfred's ray, resident manta ray	N/A	Migratory	
Pristis clavata	Dwarf sawfish, Queensland sawfish	Vulnerable	Migratory	
Pristis pristis	Freshwater sawfish, largetooth sawfish, river sawfish, Leichhardt's sawfish, northern sawfish	Vulnerable	Migratory	
Birds				
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Operational Area
Anous stolidus	Common noddy	N/A	Migratory	
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A	

Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	
Calidris canutus	Red knot, knot	Endangered	Migratory	
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	
Fregata ariel	Lesser frigatebird, least frigatebird	N/A	Migratory	
Fregata minor	Great frigatebird, greater frigatebird	N/A	Migratory	
Numenius madagascariensis	Eastern curlew, far eastern curlew	Critically endangered	Migratory	
Papasula abbotti	Abbott's booby	Endangered	N/A	
Ardenna carneipes	Flesh-footed shearwater, Fleshy-footed shearwater	N/A	Migratory	ZPI
Ardenna pacifica	Wedge-tailed shearwater	N/A	Migratory	
Arenaria interpres	Ruddy turnstone	N/A	Migratory	
Calidris alba	sanderling	N/A	Migratory	
Calidris ruficollis	Red-necked stint	N/A	Migratory	
Calidris tenuirostris	Great knot	Critically endangered	Migratory	
Charadrius bicinctus	Double-banded plover	N/A	Migratory	
Charadrius leschenaultii	Greater sand plover, large sand plover	Vulnerable	Migratory	
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	Migratory	
Charadrius veredus	Oriental plover, oriental dotterel	N/A	Migratory	
Diomedea amsterdamensis	Amsterdam albatross	Endangered	Migratory	
Diomedea epomophora	Southern royal albatross	Vulnerable	Migratory	
Diomedea exulans	Wandering albatross	Vulnerable	Migratory	
Fregata andrewsi	Christmas Island frigatebird, Andrew's frigatebird	Endangered	Migratory	
Glareola maldivarum	Oriental pratincole	N/A	Migratory	
Hydroprogne caspia	Caspian tern	N/A	Migratory	
Limicola falcinellus	Broad-billed sandpiper	N/A	Migratory	

Limnodromus semipalmatus	Asian dowitcher	N/A	Migratory
Limosa lapponica	Bar-tailed godwit	N/A	Migratory
Limosa lapponica baueri	Bar-tailed godwit (baueri), Western Alaskan bar-tailed godwit	Vulnerable	N/A
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit, bar-tailed godwit (menzbieri)	Critically endangered	N/A
Limosa limosa	Black-tailed godwit	N/A	Migratory
Macronectes giganteus	Southern giant-petrel, southern giant petrel	Endangered	Migratory
Macronectes halli	Northern giant petrel	Vulnerable	Migratory
Numenius phaeopus	Whimbrel	N/A	Migratory
Onychoprion anaethetus	Bridled tern	N/A	Migratory
Pandion haliaetus	Osprey	N/A	Migratory
Phaethon lepturus	White-tailed tropicbird	N/A	Migratory
Phaethon lepturus fulvus	Christmas Island white-tailed tropicbird, golden bosunbird	Endangered	N/A
Phaethon rubricauda	Red-tailed tropicbird	N/A	Migratory
Philomachus pugnax	Ruff (reeve)	N/A	Migratory
Pluvialis fulva	Pacific golden plover	N/A	Migratory
Pluvialis squatarola	Grey plover	N/A	Migratory
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A
Rostratula australis	Australian painted-snipe, Australian painted snipe	Endangered	Migratory
Sterna dougallii	Roseate tern	N/A	Migratory
Sternula albifrons	Little tern	N/A	Migratory
Sternula nereis nereis	Australian fairy tern	Vulnerable	N/A
Sula dactylatra	Masked booby	N/A	Migratory
Sula leucogaster	Brown booby	N/A	Migratory
Sula sula	Red-footed booby	N/A	Migratory
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	Migratory
Thalassarche cauta	Tasmanian shy albatross	Vulnerable	Migratory
Thalassarche cauta steadi	White-capped albatross	Vulnerable	Migratory

Thalassarche impavida	Campbell albatross, Campbell black-browed albatross	Vulnerable	Migratory	
Thalassarche melanophris	Black-browed albatross	Vulnerable	Migratory	
Thalassarche steadi	White-capped albatross	Vulnerable	Migratory	
Thalasseus bergii	Crested tern	N/A	Migratory	
Tringa brevipes	Grey-tailed tattler	N/A	Migratory	
Tringa glareola	Wood sandpiper	N/A	Migratory	
Tringa nebularia	Common greenshank, greenshank	N/A	Migratory	
Tringa stagnatilis	Marsh sandpiper, little greenshank	N/A	Migratory	
Tringa totanus	Common redshank, redshank	N/A	Migratory	
Xenus cinereus	Terek sandpiper	N/A	Migratory	

7.2.8.1. Listed Threatened Species Conservation Advice & Species Recovery Plans

The Commonwealth publishes recovery plans and conservation advice for a number of species listed as threatened under the EPBC Act. These documents are intended to assist in preventing the decline, and enhance the recovery, of threatened species. The requirements of the species recovery plans and conservation advice (Table 7-4) for threatened species identified within the ZPI were considered to identify any aspects that may be applicable to the impact and risk assessment (Section 9.3 to Section 9.14).

Table 7-4: Conservation advice for EPBC Act listed threatened species identified within the ZPI considered during environmental risk assessment

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
All Vertebrate Fauna			
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia 2018)	Marine debris	No explicit management actions for non-fisheries related industries (note that management actions in the plan relate largely to management of fishing waste (e.g. “ghost” gear), and state and Commonwealth management through regulation.
Mammals			
Sei whale	Approved conservation advice *Balaenoptera borealis* (sei whale) (Threatened Species Scientific Committee 2015a)	Noise interference	Assess and manage acoustic disturbance
		Vessel disturbance	Assess and manage physical disturbance and development activities

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
Blue whale	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015a)	Noise interference	Assessing and addressing anthropogenic noise
		Vessel disturbance	Minimising vessel collisions
Fin whale	Approved conservation advice for *Balaenoptera physalus* (fin whale) (Threatened Species Scientific Committee 2015b)	Noise interference	Assessing and addressing anthropogenic noise
		Vessel disturbance	Minimising vessel collisions
Humpback whale	Approved conservation advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee 2015c)	Noise interference	For actions involving acoustic impacts (example pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways site specific acoustic modelling should be undertaken (including cumulative noise impacts)
		Vessel disturbance	Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike
Southern right whale	Conservation management plan for the southern right whale: a recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2011-2021 (DSEWPaC 2012c)	Vessel disturbance	Addressing vessel collisions
		Noise interference	Assessing and addressing anthropogenic noise
Reptiles			
Loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle, flatback turtle, olive ridley turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Light pollution	Minimise light pollution
		Chemical and terrestrial discharge (oil pollution)	Ensure that spill risk strategies and response programs include management for turtles and their habitats
		Vessel disturbance	Vessel interactions identified as a threat; no specific management actions in relation to vessels prescribed in the plan
		Noise interference	No explicit relevant management actions; noise interference identified as a threat
Leatherback turtle	Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (Threatened Species Scientific Committee 2008a)	Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
Short-nosed seasnake	Approved conservation advice for *Aipysurus apraefrontalis* (short-nosed sea snake) (Threatened Species Scientific Committee 2010a)	No additional threats identified (ex. marine debris)	None applicable
Leaf-scaled seasnake	Approved conservation advice for *Aipysurus foliosquama* (leaf-scaled sea snake) (Threatened Species Scientific Committee 2010b)	No additional threats identified (ex. marine debris)	None applicable
Sharks and Rays			
White shark	Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC 2013)	No additional threats identified (ex. marine debris)	None applicable
Northern river shark	Approved conservation advice for *Glyphis garricki* (northern river shark) (Threatened Species Scientific Committee 2014a)	Habitat degradation / modification	Implement measures to reduce adverse impacts of habitat degradation and/or modification
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Green sawfish	Approved conservation advice for green sawfish (Threatened Species Scientific Committee 2008b)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Whale shark	Approved conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee 2015d)	Vessel disturbance	Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath
Grey nurse shark (west coast population)	Recovery plan for the grey nurse shark (*Carcharias taurus*) (Department of the Environment 2014)	No additional threats identified (ex. marine debris)	None applicable
Dwarf sawfish	Approved conservation advice for *Pristis clavata* (dwarf sawfish) (Threatened Species Scientific Committee 2009)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
Freshwater sawfish	Approved conservation advice for *Pristis pristis* (largetooth sawfish) (Threatened Species Scientific Committee 2014b)	Habitat degradation / modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)		Identify risks to important sawfish and river shark habitat and measures need to reduce those risks
Birds			
Migratory shorebird species[3]	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia 2015c)	Habitat degradation / modification	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes
Albatrosses and giant petrels[4]	National recovery plan for threatened albatrosses and giant petrels (DSEWPaC 2011)	Marine pollution	No explicit relevant management actions; pollution identified as a threat
Australian lesser noddy	Approved Conservation Advice for *Anous tenuirostris melanops* (Australian lesser noddy) (Threatened Species Scientific Committee 2015e)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Red knot, knot	Approved Conservation Advice for *Calidris canutus* (Red knot) (Threatened Species Scientific Committee 2016a)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat
Curlew sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (Threatened Species Scientific Committee 2015f)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat
Eastern curlew	Conservation advice *Numenius madagascariensis* eastern curlew (Threatened Species Scientific Committee 2015g)	Pollution / contamination	No explicit relevant management actions; pollution identified as a threat
Abbott's booby	Approved Conservation Advice for *Papasula abbotti* (Abbott's booby) (Threatened Species Scientific Committee 2015h)	No threats identified	None applicable
Great knot	Conservation advice *Calidris tenuirostris* great knot	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat

[3] Red knot, great knot, greater sand plover, lesser sand plover and bar-tailed godwit.

[4] Several albatrosses and giant petrels were identified as potentially occurring: Amsterdam albatross, southern royal albatross, wandering albatross, southern giant-petrel, northern giant petrel, soft-plumaged petrel, Indian yellow-nosed albatross, Tasmanian shy albatross, white-capped albatross, Campbell albatross, black-browed albatross, white-capped albatross.

Species / Sensitivity	Recovery plan / conservation advice (date issued)	Key threats identified in the recovery plan/conservation advice	Relevant Conservation Actions
	(Threatened Species Scientific Committee 2016b)		
Greater sand plover	Approved Conservation Advice for *Charadrius leschenaultii* (Greater sand plover) (Threatened Species Scientific Committee 2016c)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Lesser sand plover	Approved Conservation Advice for *Charadrius mongolus* (Lesser sand plover) (Threatened Species Scientific Committee 2016d)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Soft-plumaged petrel	Conservation advice *Pterodroma mollis* soft-plumage petrel (Threatened Species Scientific Committee 2015i)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Bar-tailed godwit (baueri)	Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan) (Threatened Species Scientific Committee 2016e)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat
Australian painted snipe	Approved Conservation Advice on *Rostratula australis* (Australian Painted Snipe) (Threatened Species Scientific Committee 2013)	Habitat degradation / modification	No explicit relevant management actions; habitat degradation/ modification identified as a threat

7.2.8.2 Biologically Important Areas & Habitat Critical for the Survival of a Species

The Department of the Environment and Energy (now the Department of Agriculture, Water and the Environment) have established a series of Biologically Important Areas (BIAs) for regionally significant marine species (which are typically listed as threatened under the EPBC Act). BIAs identify areas where biologically significant behaviours may occur, such as nesting, breeding, migrating, foraging or resting. The collection of BIAs were developed by the DAWE during the development of bioregional plans utilising a range of data, such as expert advice and published literature. BIAs are intended to assist decision-making under the EPBC Act.

Habitats critical for the survival of several species of marine turtles were identified in the *Recovery Plan for Marine Turtles in Australia 2017-2027* (Commonwealth of Australia 2017). Like BIAs, these critical habitats identify areas where biologically significant behaviours may occur. Unlike BIAs, habitats critical for the survival of a species receive specific protection under the EPBC Act. While BIAs do not receive specific protection under the EPBC Act, the threatened and migratory species associated with them are MNES and are protected under the EPBC Act.

A review of the Conservation Values Atlas identified that there are no BIAs or critical habitats within the Operational Area. A number of BIAs and critical habitats occur within the ZPI. These BIAs and critical habitats are summarised in Table 7-5. Refer to the species-specific discussions in Sections 7.2.8.4 Marine Mammals, 7.2.8.5 Reptiles, 7.2.8.6 Sharks and Rays, and 7.2.8.7 Birds for further information.

Table 7-5: BIAs and Critical Habitats(*) within the ZPI nearest to Prelude

Common Name	BIA Behaviour	Distance from Prelude (km)
Marine Mammals		
Blue and pygmy blue whales	Migration	78
	Foraging	132
Humpback whale	Migration	145
	Calving	145
	Resting	145
	Nursing	145
	Migration (north and south)	327
Dugong	Foraging (high density seagrass beds)	168
	Foraging	176
	Calving	176
	Breeding	176
	Nursing	176
Australian snubfin dolphin	Foraging	187
	Breeding	190
	Foraging (high density prey)	190
	Calving	190
	Resting	190
Indo-Pacific humpback dolphin	Foraging	190
	Calving	190
	Breeding	190
	Foraging (high density prey)	190
	Significant habitat - unknown behaviour	247
Indo-Pacific/spotted bottlenose dolphin	Calving	190
	Foraging	190
	Breeding	239
Reptiles		
Flatback turtle	Inter-nesting buffer	268
	Foraging	344
	Nesting*	302
	Inter-nesting	356
	Mating	1,005
	Migration corridor	1,005

Common Name	BIA Behaviour	Distance from Prelude (km)
	Aggregation	1,114
Green turtle	Nesting*	43
	Foraging and inter-nesting buffer	23
	Inter-nesting buffer	121
	Inter-nesting	169
	Mating	174
	Migration corridor	1,005
	Aggregation	1,114
	Basking	1,130
Hawksbill turtle	Foraging	141
	Inter-nesting buffer	150
	Nesting	169
	Nesting*	971
	Mating	1,005
	Migration corridor	1,005
	Inter-nesting	1,005
Loggerhead turtle	Foraging	344
	Inter-nesting buffer	986
	Nesting	1,008
	Nesting*	1,285
	Inter-nesting	1,688
Olive ridley turtle	Nesting – critical habitat*	177
	Foraging	344
Sharks and Rays		
Whale shark	Foraging	33
	Foraging (high prey density)	1,329
Dwarf sawfish	Foraging	203
	Nursing	416
Freshwater sawfish	Pupping	416
	Foraging	416
	Nursing	433
Green sawfish	Foraging	203
	Pupping	454
	Nursing	769
Birds		
Red-footed booby	Breeding	59
Greater frigatebird	Breeding	59

Common Name	BIA Behaviour	Distance from Prelude (km)
Lesser frigatebird	Breeding	60
Wedge-tailed shearwater	Breeding	61
	Foraging (in high numbers)	1,747
White-tailed tropicbird	Breeding	68
Brown booby	Breeding	118
Lesser crested tern	Breeding	141
Little tern	Resting	142
	Breeding	245
Roseate tern	Breeding	142
	Resting	571
Fairy tern	Breeding	991
Bridled tern	Foraging (in high numbers)	1,747
Sooty tern	Foraging	1,772
Little shearwater	Foraging (in high numbers)	1,826
White-faced storm petrel	Foraging (in high numbers)	1,837

7.2.8.3 Seasonal Sensitivities of Threatened Species

Periods of the year coinciding with key environmental sensitivities for the Operational Area and the wider regional context (ZPI), including EPBC Act listed threatened and/or migratory species potentially occurring within the Operational Area are presented in Table 7-6. These relate to breeding, foraging or migration of the indicated fauna.

Table 7-6: Key environmental sensitivities and indicative timings for migratory fauna within the Operational Area and ZPI (North-west Marine Region)

Species	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Mammals												
Blue whale[1,2]												
Humpback whale[3,4]												
Reptiles												
Loggerhead turtle[5]	H	H	H							N	N	H
Green turtle[6,7]	N,H	N,H	H	H	H							N
Hawksbill turtle[8]	N,H	H	H							N	N	N,H
Olive ridley turtle[9]												
Flatback turtle[10]	N					N	N	N	N	N	N	N
Birds												
Migratory shorebirds[11]												

	Species likely to be present
	Peak period. presence of animals reliable and predictable each year
N	Peak Turtle Species Nesting
H	Peak Turtle Species Hatching
1 - Commonwealth of Australia (2015a), 2 - Double et al. (2014), 3 - Jenner and Jenner (2001), 4 - Double et al. (2012a), 5 - Limpus (2008a), 6 - Limpus (2008b), 7 - Guinea (2010), 8 - Limpus (2009a), 9 - Limpus (2008c), 10 - Limpus (2007), 11 - Rogers et al. (2011)	

7.2.8.4 Marine Mammals

Sei Whale

Sei whales (*Balaenoptera borealis*) have a global distribution. Though sightings are uncommon, the species may be seen in coastal and offshore waters throughout Australia, as well as the waters surrounding Christmas and Cocos Keeling Islands (Bannister et al. 1996, DoEE 2019). The species utilises a range of marine habitats, which has been attributed to a combination of dynamic physical and prey processes (DoEE 2019).

Sei whale migratory movements are well defined (distinctly north-south) with the species moving between polar, temperate and tropical waters for foraging and breeding. The species feeds intensively between the Antarctic and sub-Antarctic boundary on planktonic crustaceans (Bannister et al. 1996, DoEE 2019). The species does not dive, rather it sinks, and tends to swim at shallower depths comparative to other species (DoEE 2019).

There are no mating or calving areas in Australian waters, nor are there any recognised BIAs or critical habitat. Sei whales may occur within the Operational Area and ZPI, but are expected to occur only in low numbers.

Bryde's Whale

The Bryde's whale was identified as potentially occurring within the Operational Area and ZPI. The Bryde's whale occurs in tropical and temperate waters (Bannister et al. 1996). Bryde's whales occur in both oceanic and inshore waters with the only key localities recognised in Western Australia being in the Abrolhos Islands and north of Shark Bay (Bannister et al. 1996). Two forms are recognised: inshore and offshore Bryde's whales. It appears that the offshore form may migrate seasonally, heading towards warmer tropical waters during the winter, however, behaviour of the offshore form in the Indian Ocean is not well documented.

Bryde's whales may occur through a broad area of the continental shelf in the region, including the Operational Area and the ZPI. The noise monitoring study undertaken for the Barossa project detected Bryde's whales in the Timor Sea almost year-round (January to October) (McPherson et al. 2016). Bryde's whales have also been detected on the North West Shelf (south-west of the Operational Area) from mid-December to mid-June, peaking in late February to mid-April (RPS Environment and Planning 2012).

Bryde's whale may be encountered within the Operational Area and ZPI year-round in low numbers, particularly in oceanic and continental slope waters.

Blue Whale

There are two recognised subspecies of blue whale in the Southern Hemisphere, both of which are recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus*) and the 'pygmy' blue whale (*Balaenoptera musculus brevicauda)* (Commonwealth of Australia 2015a). Both are listed as Endangered under the EPBC Act. In general, southern blue whales occur in waters south of 60 °S and pygmy blue whales occur in waters north of 55 °S (i.e. not in the Antarctic) (Department of the Environment and Heritage 2005). On this basis, nearly all blue whales sighted are likely to be pygmy blue whales. The *Conservation Management Plan for the Blue Whale* (Commonwealth of Australia 2015a) has delineated the distribution area of blue whales in Australian waters and identified a number of BIAs for blue whales for Commonwealth waters (migratory corridor and foraging areas) (Table 7-6).

Recent tagging studies (Double et al. 2014) indicate the general migration pattern, timing and key areas for pygmy blue whales in Commonwealth waters are the Perth Canyon/Naturaliste Plateau and Ningaloo Reef/North West Cape (beyond the ZPI). Satellite tagging of pygmy blue whales off the Perth Canyon confirmed the general distribution of migrating pygmy blue whales was offshore in water depths over 200 m and commonly over 1,000 m (Double et al. 2012b). These data showed that whales tagged during March and April migrated northwards post tag deployment. The tagged whales travelled relatively near to the Australian coastline (100 ± 2 km) until reaching North West Cape after which they travelled offshore (238 ± 14 km). Whales reached the northern terminus of their migration and potential breeding grounds in Indonesian waters by June (Double et al. 2014). The southbound migration is thought to terminate in the Southern Ocean, where the species feeds.

No pygmy blue whale BIAs overlap the Operational Area; two BIAs were identified within the ZPI (Table 7-6). These are:

- A broad migration corridor along the coast of Western Australia, approximately 78 km west of the Prelude FLNG facility; and
- A potential foraging area around Scott Reef, approximately 132 km west of the Prelude FLNG facility.

Based on these tagging studies and the locations of the BIAs relative to the Operational Area, pygmy blue whales are unlikely to occur in the Operational Area due to their preference for deeper waters, but are expected to be seasonally present within the ZPI.

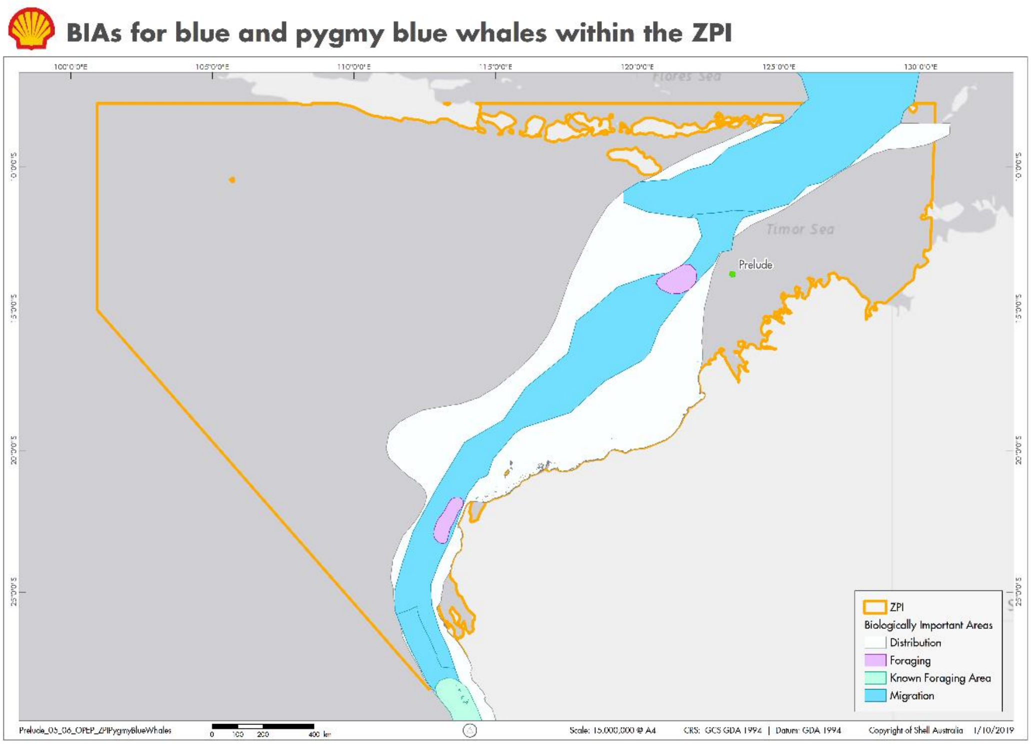

Figure 7-6: BIAs for blue and pygmy blue whales within the ZPI

Fin Whale

Fin whales (*Balaenoptera physalus*) are widely distributed from polar to tropical waters and have been recorded in all Australian states, other than New South Wales and the Northern Territory (Bannister et al. 1996). The species is listed as Vulnerable under the EPBC Act.

Fin whales are rarely observed in inshore waters and displays migratory movements (essentially north-south) between polar, temperate and tropical waters (Bannister et al. 1996). Migration within Australian waters does not appear to follow a clear route and is thought to occur in summer and autumn. Breeding in the Southern hemisphere occurs in tropical and sub-tropical latitudes between May and July.

Fin whales feed on planktonic crustacea, such as Antarctic krill, and primarily forage in high latitudes (Bannister et al. 1996). Within Australian waters, Antarctic waters and the Bonney Upwelling are thought to be important foraging grounds for this species.

There are no recognised BIAs or critical habitats for fin whales within the Operational Area or the ZPI. The species may occur within the Operational Area or ZPI, but is not expected to be particularly abundant.

Humpback Whales

The humpback whale (*Megaptera novaeangliae*) has a wide distribution, with recordings throughout Australian Antarctic waters and offshore from all Australian states (Bannister et al. 1996). Humpback whales are listed as Vulnerable under the EPBC Act.

Humpback whales migrate between summer feeding grounds in Antarctica and winter breeding and calving grounds in the sub-tropical and tropical inshore waters of north-west Australia (Jenner et al. 2001). Humpback whales breed and calve in continental shelf waters off northern Western Australia, with the area between Broome and the northern end of Camden Sound hosting large numbers of humpback whales from June to September each year (Double et al. 2012a, 2010). Camden Sound is considered to be the northern limit of most migrating humpback whales; hence the species is unlikely to occur within the Operational Area but will be seasonally present within the ZPI.

Within the wider ZPI, a BIA area has been identified for the humpback whale. The behaviour of the humpback whale within this BIA, located approximately 145 km south of the Operational Area is resting, calving, migrating and nursing (Figure 7-7).

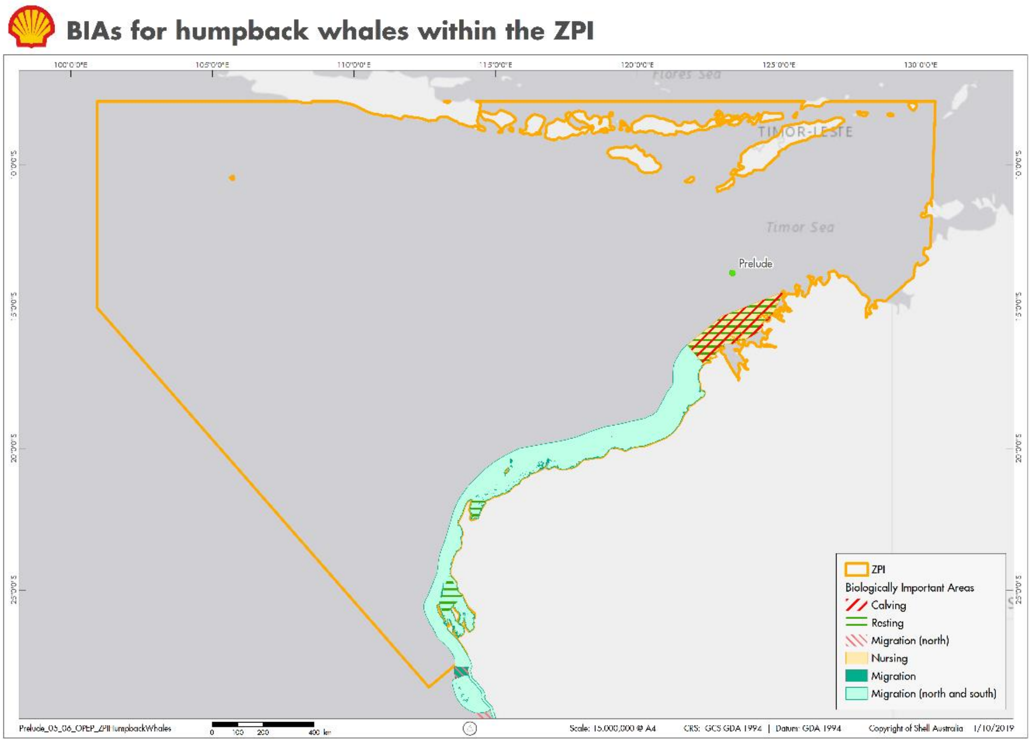

Figure 7-7: BIAs for humpback whales within the ZPI

Killer Whale

Killer whales (*Orcinus orca*) have a global distribution and utilise a wide range of habitats. However, they appear to be primarily concentrated in temperate coastal waters and cooler regions of high productivity (Bannister et al. 1996).

This species is distributed throughout Australian waters, in particular in Tasmanian waters and the waters surrounding Macquarie Island (1,500 km south-south-east of Tasmania) (Bannister et al. 1996). Off Australia, the species is typically observed moving along the continental slope and shelf, and near seal colonies (Bannister et al. 1996). There are no key localities identified within continental Australian waters for this species. Killer whales are carnivores and their diet varies seasonally and regionally (Bannister et al. 1996).

Globally killer whales are known to migrate; however, specific routes and seasonal movement patterns are not known in detail and are thought to relate to prey availability (Bannister et al. 1996). Mating occurs year-round and there are no known calving areas in Australian waters (Bannister et al. 1996).

Based on their known distribution and movements, killer whales may be encountered in within the Operational Area and ZPI in low numbers.

Sperm Whale

Sperm whales (*Physeter microcephalus)* occur in deep waters in all oceans, typically remaining at depths of 200 m or greater, and are known to occur throughout Australian waters (Bannister et al. 1996). Key areas for sperm whales occur in continental shelf waters approximately 20 nautical miles (nm) to 30 nm offshore between Cape Leeuwin and Esperance (Bannister et al. 1996), several thousand kilometres from the ZPI.

Sperm whales have a diverse diet, although they primarily feed on oceanic squid (Bannister et al. 1996). Migration patterns vary between sex. Mature females and juveniles are thought to be resident in tropical and subtropical waters throughout the year, whereas mature males are thought to migrate between the tropics and Antarctic (Bannister et al. 1996).

Considering the known distribution of the species, sperm whales may transit through the Operational Area and ZPI in low numbers.

Spotted Bottlenose Dolphin

The spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*) occurs primarily in continental shelf waters (< 200 m deep), nearshore and in areas with rocky or coral reefs, sandy or soft sediments, or seagrass beds (DSEWPaC 2012d). Small populations also occur in the inshore waters of some oceanic and continental shelf islands, such as the Rowley Shoals and Scott Reef (DSEWPaC 2012d). No BIAs occur within the Operational Area. Several BIAs occur within the ZPI (primarily within the Lalang-garram / Camden Sound Marine Park), including foraging and calving (190 km south of Prelude) and breeding (239 km south of Prelude).

Migration patterns for the species in Australia are variable, including of year-round residency in small areas, long-range movements and migration. Due to their tendency to shallow water areas it is unlikely that the species will occur in the Operational Area, but is likely to occur in coastal waters in the ZPI.

Antarctic Minke Whale

The Antarctic minke whale is distributed worldwide and has been recorded off all Australian states, feeding in cold waters and migrating to warmer waters to breed. It is not expected to occur in the Operational Area, but may occur within the ZPI. It is thought that the Antarctic minke whale migrates up the WA coast to approximately 20°S to feed and possibly breed (Bannister et al. 1996); however, detailed information on timing and location of migrations and breeding grounds is not well known. No critical habitats or BIAs for Antarctic minke whales occur within the Operational Area or ZPI.

Given the wide distribution of Antarctic minke whale, the ZPI is unlikely to represent an important habitat for this species. Antarctic minke whales are not expected to occur within the Operational Area or ZPI in large numbers.

Dugong

Dugongs (*Dugong dugon*) occur in tropical and sub-tropical coastal and island waters broadly coincident with the distribution of seagrasses (Marsh et al. 2002), which typically occur in shallow intertidal zone areas to water depths of around 25 m. Dugong feeding aggregations tend to occur in large seagrass meadows within wide shallow protected bays, shallow mangrove channels and in the lee of large inshore islands. The movements of most individuals are limited to within tens of kilometres within the vicinity of seagrass beds (Marsh et al. 2002). However, some individuals have been observed to travel large distances of up to 600 km over a few days (Marsh et al. 2002).

Dugongs and areas of potential dugong habitat exist along the majority of northern Australian coastline from Shark Bay in Western Australia to Moreton Bay in Queensland. A small population of approximately 50 individuals exists at Ashmore Reef, which is considered to be genetically distinct from other nearby Australian or Indonesian populations (Commonwealth of Australia 2002).

Several BIA's for dugong overlap the ZPI, the nearest of which is the foraging (high density seagrass beds BIA around Cartier Island approximately 168 km north of the

Prelude FLNG facility. Other BIAs for foraging, breeding, calving and nursing occur within the ZPI around Ashmore Reef and the Dampier Peninsula.

Considering the habitat preference of the species, dugongs are very unlikely to occur within the Operational Area but are expected to occur in coastal waters and around islands in the ZPI.

Southern Right Whale

The southern right whale occurs primarily in waters between approximately 20° and 60°S and moves from high latitude feeding grounds in summer to warmer, low latitude, coastal locations in winter (Bannister et al. 1999). These latitudes are far to the south of the Operational Area, which is at approximately 13.7°S. Southern right whales aggregate in calving areas along the south coast of Western Australia, such as Doubtful Island Bay, east of Israelite Bay and to a lesser extent Twilight Cove (DSEWPaC 2012b). During the calving season, between May and November, female southern right whales that are either pregnant or with calf can be present in shallow protected waters along the entire southern Western Australian coast and west up to approximately Two Rocks, north of Perth. Sightings in more northern waters are relatively rare; however, they have been recorded as far north as Exmouth (Bannister et al. 1996). There are no southern right whale BIAs within the Operational Area or ZPI.

Given the species prefers temperate waters and has rarely been recorded north of Exmouth, southern right whales will not occur in the Operational Area and are very unlikely to occur in the ZPI.

Australian Snubfin Dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*, also known as the Irrawaddy dolphin, *O. brevirostris*) shares similar habitat preferences with the Indo-Pacific humpback dolphin, occurring in shallow coastal and estuarine waters (typically less than 20 m deep) (DSEWPaC 2012d). However, as with the Indo-pacific humpback dolphin, the species has also been recorded up to 23 km offshore. In Australia, the species distribution covers the coastal waters of Queensland, the Northern Territory and northern Western Australia. The population in Australian waters is thought to be continuous with the Papua New Guinea species but separate from populations in Asia.

This species is not expected to occur within the Operational Area due to its preference for coastal habitats, but may be present in coastal areas of the ZPI. No BIAs occur within the Operational Area. Several BIAs occur within the ZPI (primarily within the Lalang-garram / Camden Sound Marine Park), including foraging, breeding, resting and calving (190 km south of Prelude).

Indo-Pacific (Australia) Humpback Dolphin

The Indo-Pacific humpback dolphin has been recognised as two distinct species; the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Australian humpback dolphin (*S. sahulensis*) (Jefferson and Rosenbaum 2014). Only the Australian humpback dolphin is considered here. Humpback dolphins inhabit shallow coastal, estuarine habitats in tropical and subtropical regions generally in depths of less than 20 m (Corkeron et al. 1997, Jefferson 2000, Jefferson and Rosenbaum 2014).

The Australian humpback dolphin (*Sousa sahulensis*) occurs along the northern Australian coastline from Exmouth in Western Australia to the Queensland/New South Wales border (Bannister et al. 1996). The species' preferred habitat is shallow (generally < 20 m in depth) coastal, estuarine and riverine (occasional) waters.

However, individuals have been observed in shallow waters up to 55 km offshore (Bannister et al. 1996).

Given the species' preferred habitat is relatively shallow coastal waters, Australian humpback dolphins are very unlikely to occur in the Operational Area, but may be present in coastal areas of the ZPI. There are several BIAs within the ZPI along the Kimberley coast, including foraging, breeding, calving and resting, the closest of which is approximately 190 km from the Prelude FLNG facility.

7.2.8.5 Reptiles

Loggerhead Turtle

The loggerhead turtle (*Caretta caretta*) is distributed throughout tropical and sub-tropical and temperate waters in all ocean basis. In Australia, the species ranges along most of the coastline, but is rare in temperate waters (Commonwealth of Australia 2017). Nesting in Australia is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia. Foraging areas are more widely distributed with the Western Australian stock foraging from Shark Bay through to Arnhem Land, Gove and into the Java Sea of Indonesia (Limpus 2008a). Loggerhead turtles are carnivorous and mainly feed on benthic invertebrates in a wide range of habitats ranging from nearshore to 55 m in depth (Commonwealth of Australia 2017).

Loggerhead turtles may occur within the Operational Area and the ZPI. A foraging BIA for the loggerhead turtle lies within the ZPI approximately 344 km east from the Prelude FLNG facility. The nearest critical habitat for loggerhead turtles defined by the Recovery plan for marine turtles in Australia 2017-2027 (Commonwealth of Australia 2017) is the nesting habitat around North West Cape, approximately 1,285 km south-west from Prelude.

Green Turtle

The green turtle (*Chelonia mydas*) is distributed in tropical and sub-tropical waters in the Pacific, Atlantic and Indian oceans. Within Australian waters, the species is predominately found off the Western Australia, Northern Territory and Queensland coastlines (Commonwealth of Australia 2017). The population at Ashmore Reef and Cartier Island is thought to nest year-round, with a peak in nesting during December and January; hatchling emergence is thought to be highest during May (Limpus 2008b).

The species is primarily herbivorous and forages on algae, seagrass and mangroves, including where these habitats exist at offshore coral reef habitats (Commonwealth of Australia 2017). Tagging studies have shown that green turtles can move considerable distances between nesting, with movements of 100's to 1,000's of kilometres recorded (Limpus 2008b).

No BIAs or habitats critical for the survival of green turtles overlap the Operational Area. The nearest habitat critical for the survival of green turtles is the nesting habitat around Browse Island; this habitat lies approximately 23 km south-east of the Prelude FLNG facility at the closest point. Other critical nesting habitat within the ZPI is distributed around offshore islands in the Timor Sea and along the Kimberley coast (Figure 7-8). There are also a number of BIAs for green turtles within the ZPI, none of which overlap the Operational Area:

- Foraging and inter-nesting buffer (23 km south-east of Prelude)
- Inter-nesting buffer (121 km north of Prelude)

- Nesting (141 km north of Prelude FLNG facility)
- Inter-nesting (169 km west of Prelude FLNG facility)
- Mating (174 km north of Prelude FLNG facility).

Green turtles may occur throughout the Operational Area, but would only be expected to occur in low numbers due to the absence of foraging or nesting habitat. Green turtles may be present throughout the ZPI, and are likely to be more abundant around nesting beaches and shallow foraging habitats.

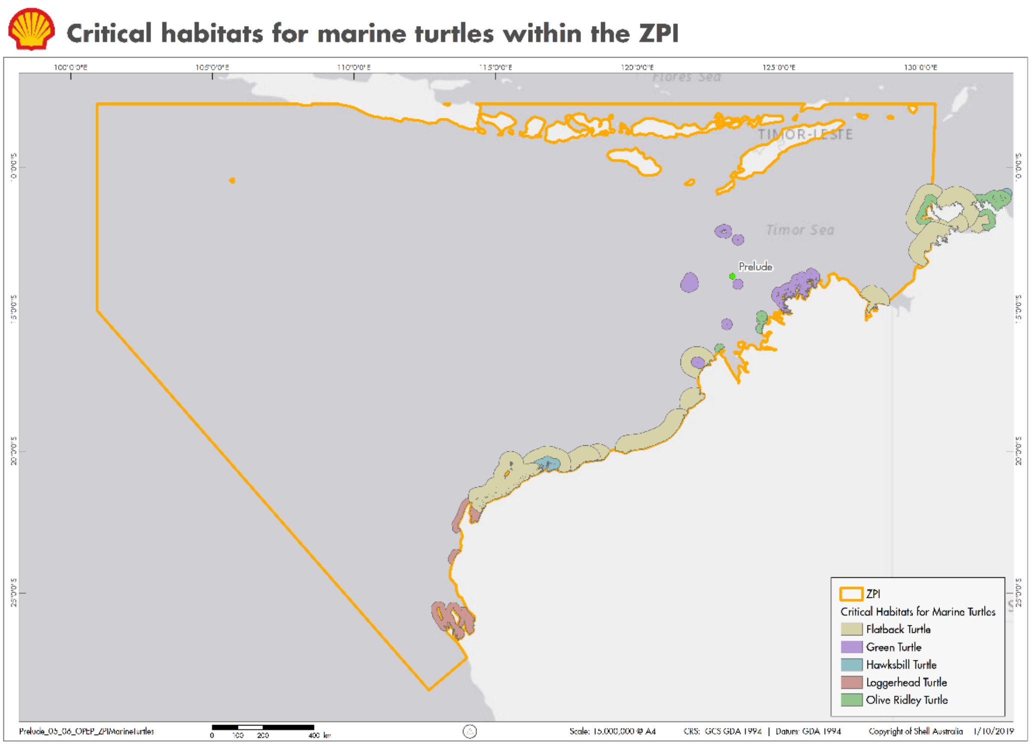

Figure 7-8: Critical habitats for marine turtles within the ZPI

Leatherback Turtle

The leatherback turtle (*Dermochelys coriacea*) is distributed in tropical and temperate oceans worldwide. The species is known to forage and migrate throughout the open offshore waters of Australia, with a distribution that extends further south into temperate waters than other marine turtle species (Limpus 2009b). Records of leatherback turtle nesting in Australia are sparse and limited to the Cobourg Peninsula and Queensland coast (Limpus 2009b). There have been no confirmed accounts of nesting on beaches along Western Australia's coastline. Leatherback turtles eat almost exclusively jellyfish and are pelagic throughout their life in oceanic waters around Australia (Limpus 2009b).

There are no BIAs or habitats critical for the survival of leatherback turtles within the Operational Area and ZPI. Leatherback turtles may occur within the Operational Area and ZPI in low numbers throughout the year.

Hawksbill Turtle

The hawksbill turtle (*Eretmochelys imbricata*) has a worldwide distribution in tropical and sub-tropical waters. In Australia, hawksbill turtles predominately occur along the northern Western Australia, Northern Territory and northern Queensland coastlines (Limpus 2009a).

This species is typically associated with rocky and coral reef habitats and is expected to be found foraging within these habitats along the Western Australian coastline, from Shark Bay to the northern extent of the North West Marine Region (Commonwealth of Australia 2017a). Hawksbill turtles are omnivorous and feed on algae, sponges, soft corals and soft bodied-invertebrates.

The population in Western Australia is thought to nest primarily between October and January, while there is evidence of year-round breeding and nesting in the Northern Territory and northern Queensland stocks (Limpus 2009a).

There are no habitats critical for the survival of hawksbill turtles within the Operational Area or the ZPI. There are a number of BIAs for hawksbill turtles within the ZPI:

- Foraging (141 km north of Prelude FLNG facility)
- Inter-nesting buffer (150 km west of Prelude FLNG facility)
- Nesting (169 km west of Prelude FLNG facility).

Hawksbill turtles may occur throughout the Operational Area, but would only be expected to occur in low numbers due to the absence of foraging or nesting habitat. Hawksbill turtles may be present throughout the ZPI, and are likely to be more abundant around nesting beaches and shallow foraging habitats.

Olive Ridley Turtle

The olive ridley turtle (*Lepidochelys olivacea*) has worldwide tropical and sub-tropical distribution. In Australia, the species primarily occurs primary in the Northern Territory and Queensland; the component of the Australian population in Western Australian waters is relatively small (Limpus 2008c).

The olive ridley turtle is primarily carnivorous and feed predominantly on soft-bodied invertebrates (Commonwealth of Australia 2017). The species is known to feed in water depths between 15 m and 200 m, and may make movements > 1,000 km between their nesting and foraging grounds (Whiting et al. 2007).

Nesting is known to occur in the Northern Territory and on western Cape York (Queensland) (Commonwealth of Australia 2017, Limpus 2008c); low density nesting has also been described on the Kimberley coast (Limpus 2008c).

No BIAs or habitats critical for the survival of the olive ridley turtle occur within the Operational Area. Nesting habitat critical for the survival of the olive ridley turtle does occur within the ZPI (Figure 7-8), centred on several islands along the Kimberley coastline, the nearest of which is approximately 177 km south of Prelude. The nearest olive ridley BIA to the Prelude FLNG facility is a foraging BIA, which lies approximately 344 km to the east.

Olive ridley turtles may occur within the Operational Area and the ZPI, but are only expected to be present in low numbers.

Flatback Turtle

The flatback turtle (*Natator depressus*) is known to occur along the Western Australia, Northern Territory and Queensland coastlines, and forages widely across the Australian continental shelf and into the continental waters off Indonesia and Papua New Guinea (Commonwealth of Australia 2017). Unlike other species of marine turtle, the flatback turtle does not have a global tropical distribution, with all recorded nesting beaches within Australian waters (Limpus 2007).

Flatback turtles nest throughout tropical Australia, although there are several distinct populations (Limpus 2007). The northerly populations in Queensland and the Northern Territory nest year-round with a peak during winter months. Populations at higher latitudes off central Queensland and Western Australia's Pilbara coast tend to have a nesting peak in summer (Limpus 2007).

Flatback turtles are primarily carnivorous and feed predominantly on soft-bodied invertebrates in relatively shallow waters (Limpus 2007). Their distribution is largely restricted to continental shelf waters (< 200 m).

There are no BIAs or habitats critical for the survival of flatback turtles within the Operational Area. Habitat critical for the survival of flatback turtles does occur within the ZPI, the closest of which is the inter-nesting habitat on the western Dampier Peninsula, approximately 302 km south of the Prelude FLNG facility. There are several BIAs within the ZPI, including:

- Inter-nesting buffer (268 km south of the Prelude FLNG facility)
- Foraging (344 km east of the Prelude FLNG facility)
- Inter-nesting (360 km south of the Prelude FLNG facility)
- Nesting (360 km south of the Prelude FLNG facility).

Flatback turtles are unlikely to occur within the Operational Area, but are expected to occur within the ZPI, particularly in suitable foraging habitat in coastal waters and around nesting beaches.

Short-nosed Seasnake

The short-nosed seasnake (*Aipysurus apraefrontalis*) is a slender marine snake with a small head and pointed snout. This species has primarily been recorded at Ashmore Reef and Cartier Island on the Sahul Shelf, which lie approximately 169 km north of the Prelude FLNG facility. The species has also been recorded along the Pilbara coast between Exmouth Gulf and Broome (Threatened Species Scientific Committee 2010a).

Like all seasnakes, the short-nosed seasnake must come to the surface to breathe at intervals anywhere between 30 minutes and two hours. The species has been recorded primarily in reef flats or in shallow waters (< 10 m). The short-nosed seasnake has apparently experienced a decline in numbers, with recent surveys of Ashmore Reef failing to observe the species (Threatened Species Scientific Committee 2010a).

The short-nosed seasnake is unlikely to occur within the Operational Area, but may occur within shallow reef habitat within the ZPI.

Leaf-scaled Seasnake

The leaf-scaled seasnake (*Aipysurus foliosquama*) is a slender marine snake growing up to 60 cm in total length with some specimens found up to 90 cm. Like the short-nosed seasnake, the leaf-scaled seasnake is thought to be largely restricted to the reefs of the Sahul Shelf in Western Australia, especially on Ashmore and Hibernia Reefs (Threatened Species Scientific Committee 2010b).

The short-nosed seasnake is unlikely to occur within the Operational Area, but may occur within shallow reef habitat within the ZPI.

Saltwater Crocodile

The salt-water crocodile occurs within the nearshore marine and estuarine waters throughout southern Asia and Northern Australia. Large populations within the major river systems of the Kimberley occur in the rivers draining into the Cambridge Gulf, the Prince Regent and Roe River systems of the east and northwest Kimberley. There are no BIAs for the species within the Operational Area or ZPI. Saltwater crocodiles are very unlikely to occur in the Operational Area, but may be present within the coastal waters, estuaries and tidal creeks of the Kimberley region within the ZPI.

7.2.8.6 Sharks and Rays

Narrow Sawfish

The narrow sawfish is widely distributed throughout the Indo-Pacific region, with records spanning from the Arabian Gulf to Japan. In Australia, the species may have a broad tropical distribution from approximately North West Cape in Western Australia to southern Queensland. Like other sawfish species, the narrow sawfish has experienced considerable decline in numbers due to human activities, including fishing and habitat loss / damage (Cavanagh et al. 2003).

Like other sawfish in the family Pristidae, the narrow sawfish prefers shallow coastal, estuarine and riverine habitats, although may occur in waters up to 40 m deep (D’Anastasi et al. 2013). There are no BIAs for this species within the Operational Area or the ZPI. Given the water depth and distance from preferred habitats, narrow sawfish are not expected to occur within the Operational Area. However, the species may be found in shallow coastal waters and estuaries within the ZPI.

White Shark

The white shark (*Carcharodon carcharias*) has a circumglobal distribution primarily in temperate waters. In Australian waters, the species typically occurs in temperate and sub-tropical waters between the shore and the 100 m depth contour; however, adults and juveniles have been recorded diving to depths of 1,000 m (Bruce 2008, Bruce et al. 2006). Tagging studies indicate white sharks may move as far north as Rockhampton on the Queensland coast, however they are thought to be very uncommon in tropical waters (Bruce et al. 2006), such as the Timor Sea.

There are no BIAs for white sharks within the Operational Area or ZPI; given the anti-tropical distribution of this species, white sharks are unlikely to occur in the Operational Area or ZPI.

Northern River Shark

The northern river shark (*Glyphis garricki*) is a medium-sized shark which can tolerate both marine and freshwater. The species has a tropical distribution and is believed to be endemic to northern Australia and southern New Guinea (Stevens et al. 2005). In Western Australia, the majority of records of the species are from King Sound. The species is most commonly encountered in tidal creeks and estuaries (Morgan et al. 2010), hence it is unlikely to occur within the Operational Area but may be present in

Kimberley coastal waters in the ZPI. There are no BIAs for this species within the Operational Area or ZPI.

Shortfin Mako

The shortfin mako shark is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). The shortfin mako is commonly found in water with temperatures greater than 16 °C. Tagging studies indicate shortfin makos spend most of their time in water less than 50 m deep but with occasional dives up to 880 m (Abascal et al. 2011, Stevens et al. 2010).

The species can grow to almost 4 m in length. Females mature later (19 to 21 years) than males (7 to 9 years) and adults have moderate longevity estimates of 28 to 29 years (Bishop et al. 2006).

The shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana et al. 2005). Little is known about the population size and distribution of shortfin mako sharks in Western Australia; they may occur in both the Operational Area and ZPI.

Longfin Mako

The longfin mako is a widely distributed, but rarely encountered, oceanic shark species. The species can grow to just over 4 m long and is found in northern Australian waters, from Geraldton in Western Australia to at least Port Stephens in New South Wales and is uncommon in Australian waters relative to the shortfin mako (Bruce 2013, Department of the Environment, Water, Heritage and the Arts 2010).

There is very little information about these sharks in Australia, with no available population estimates or distribution trends. A study from southern California documented juvenile longfin mako sharks remaining near surface waters, while larger adults were frequently observed at greater maximum depths of about 200 m (Sepulveda et al. 2004).

Longfin mako may occur in the Operational Area and ZPI, but given their widespread distribution and apparent low density they are likely to be uncommon.

Giant Manta Ray

The giant manta ray is broadly distributed in tropical waters of Australia. The species primarily inhabits near-shore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al. 2011). Giant manta rays have been recorded regularly off the Ningaloo Coast (Preen et al. 1997), well beyond the ZPI.

The Operational Area is not located in, or adjacent to, any known aggregation areas for the species (e.g. feeding or breeding). Occurrence of giant manta rays within the Operational Area is likely to be infrequent, and restricted to individuals transiting the area.

Green Sawfish

The green sawfish (*Pristis zijsron*) were once widely distributed in coastal waters along the northern Indian Ocean, although it is believed that northern Australia may be the last region where significant populations exist (Stevens et al. 2005). Within Australia, green sawfish are currently distributed from about Cairns in Queensland across northern Australian waters to Broome in Western Australia (Threatened Species Scientific Committee 2008b).

Despite records of the species in deeper offshore waters, green sawfish typically occur in the inshore fringe with a strong associated with mangroves and adjacent mudflat habitats (Commonwealth of Australia 2015b, Stevens et al. 2005). Movements within these preferred habitats is correlated with tidal movements (Stevens et al. 2008).

No BIAs for the green sawfish overlap the Operational Area. BIAs in the ZPI include foraging (203 km south of Prelude) and pupping (294 km south of Prelude) BIAs along the Kimberley coast to the south of the Operational Area. Given the habitat preferences of the green sawfish, the species is unlikely to occur within the Operational Area, but is likely to occur with the ZPI along nearshore waters and tidal creeks of the Kimberley coastline.

Whale Shark

The whale shark (*Rhincodon typus*) is globally distributed in tropical and warm temperate waters, and it is thought individuals form a single genetic population (Castro et al. 2007). The species is an epipelagic filter feeder; their diet typically consists of planktonic and nektonic species, including small crustaceans and smaller schooling fish species.

Key areas of concentration within Australian waters include the Ningaloo coast (March – July), Christmas Island (December – January) and the Coral Sea (November – December), with the timing of the aggregations thought to be linked to seasonal fluctuations in prey abundance (Threatened Species Scientific Committee 2015d). Tagging, aerial and vessel surveys of whale sharks aggregating off the Ningaloo Coast suggest that the group disperses widely. Satellite tracking has shown that the sharks may follow three migration routes from Ningaloo (Meekan & Radford 2010, Wilson et al. 2006):

- north-west, into the Indian Ocean
- directly north, towards Sumatra and Java
- north-east, passing through the NWS Province travelling along the shelf break and continental slope.

These large scale movements are consistent with observations in other parts of the world. Tagging studies in other parts of the world have recorded whale shark movements > 13,000 km (Eckert and Stewart 2001).

Based on tagging studies, a foraging BIA has been defined for whale sharks which extends along the continental slope between the Ningaloo Coast and the Timor Sea (Figure 7-9). While listed as a foraging BIA, it is more likely to represent a migration corridor for individual whale sharks moving between Indonesia and the Ningaloo Coast. This BIA does not overlap the Operational Area, but does extend through the ZPI. The whale shark is known to occur within the Operational Area, with crew onboard the Prelude FLNG facility having observed the species. Whales sharks will also occur within the ZPI.

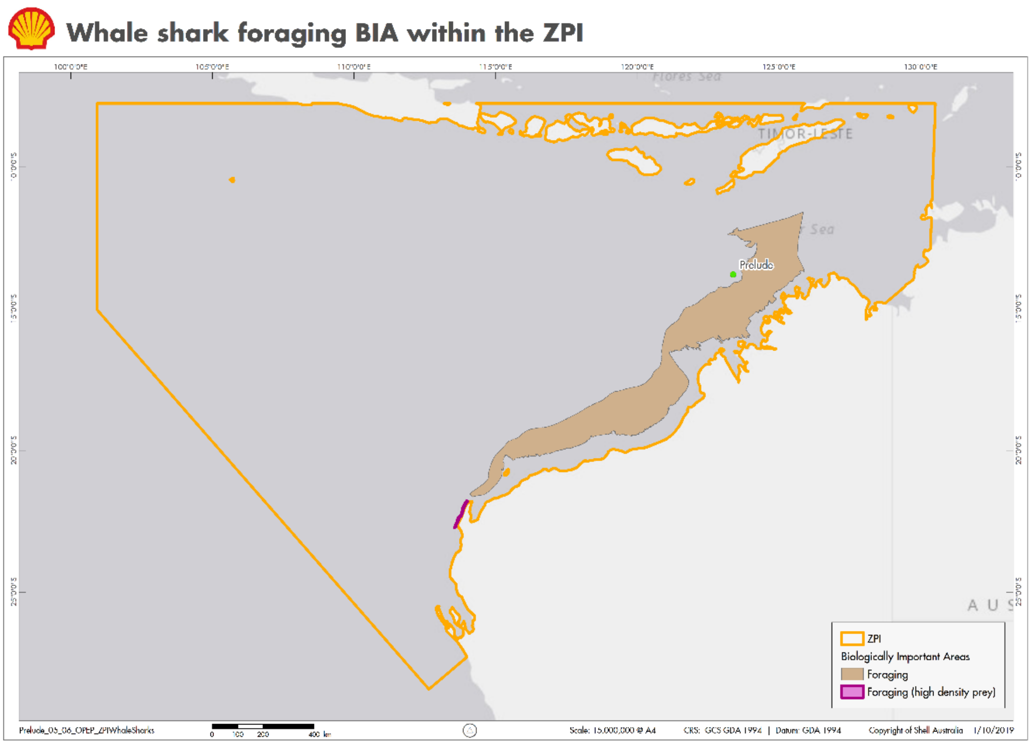

Figure 7-9: Whale shark foraging BIA within the ZPI

Grey Nurse Shark (West Coast Population)

The grey nurse shark (*Carcharus taurus*) has a broad distribution in inner continental shelf waters, primarily in sub-tropical to cool temperate waters. The species occurs primarily in south-west coastal waters between 20 and 140 m depth off Western Australia (Chidlow et al. 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs), however no clear aggregation sites have been identified off Western Australia (Chidlow et al. 2006).

No BIAs for grey nurse sharks occur within the Operational Area or the ZPI. Given the species' preference for temperate waters, it is unlikely to occur within the Operational Area or ZPI.

Porbeagle

The porbeagle is a species of lamnid shark found in temperate, sub-Arctic and sub-Antarctic waters worldwide. The species can thermos-regulate physiologically, allowing it to occupy cooler waters than other shark species. The porbeagle has a wide vertical range within the water column, with tagging studies recording the species between the surface and > 700 m water depth (Saunders et al. 2011). Given its preference for cooler waters (Bruce 2013), the porbeagle is unlikely to be encountered within the Operational Area, but may occur in the southern portion of the ZPI. There are no critical habitats or BIAs for the porbeagle in the Operational Area or ZPI.

Reef Manta Ray

The taxonomy of the reef manta ray (*Manta alfredi*) was revised relatively recently, with this species being recognised as distinct from the giant manta ray (*M. birostris*) (Marshall et al. 2009). The species is occurs in inshore waters, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest that this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations than the giant manta ray (Deakos et al. 2011, Marshall et al. 2009). A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier et al. 2011).

Reef manta rays may occur in the Operational Area, but is only expected to occur in low numbers. The species is likely to be present in the ZPI where suitable habitat is available (e.g. coastal waters and offshore reefs).

Dwarf Sawfish

The dwarf sawfish (*Pristis clavata*) is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (Kyne et al. 2013).

Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al. 2008). Juvenile dwarf sawfish utilise estuarine habitats in north-western Western Australia as nursery areas and migrate to deeper waters as adults (Thorburn et al. 2008, Threatened Species Scientific Committee 2009). The majority of capture locations for the species in Western Australia waters have occurred within King Sound (beyond the ZPI) and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al. 2010). Individuals have also been recorded from Eighty Mile Beach, and occasional individuals have also been taken from considerably deeper water by trawl fishers (Morgan et al. 2010).

Dwarf sawfish are very unlikely to occur within the Operational Area, but may be present in coastal waters within the ZPI.

Freshwater Sawfish

The freshwater sawfish (*Pristis pristis*) inhabits both riverine and marine environments in northern Australia. While primarily associated with rivers, tidal creeks and estuaries, the freshwater sawfish has been recorded up to 100 km offshore (Commonwealth of Australia 2015b).

In Western Australia, the species is known from riverine and coastal environments in the Kimberley region. Riverine habitats are particularly important as pupping habitats.

The freshwater sawfish is very unlikely to occur within the Operational Area, but may occur in coastal waters, estuaries and tidal creeks along the Kimberley coastline within the ZPI.

7.2.8.7 Birds

The Operational Area may be visited by migratory and oceanic birds but does not contain any emergent land that could be utilised as roosting or nesting habitat and contains no known critical habitats (including feeding) for any species. Observations onboard the Prelude FLNG facility indicate that seabirds and migratory shorebirds opportunistically roost onboard the facility.

Threatened and migratory bird species that may occur within the Operational Area and ZPI can broadly be classified into two groups – seabirds and migratory shorebirds. The descriptions below of the species in Table 7-3 have been based on these groups.

Seabirds

Seabirds are birds that are highly adapted to the marine environment. Characteristics of many seabird species include webbed feet, dense water-resistant plumage that protects birds from becoming soaked, a diet comprising marine biota (typically fish), and nesting on offshore islands or inaccessible coastlines. Many seabird species spend relatively little time on land and forage at sea for extended periods. Some species may undertake long migrations; however, unlike migratory shorebirds, they do not typically follow the East Asian-Australasian flyway.

Seabirds that may occur within the Operational Area and ZPI (Table 7-3) include:

- noddies:
  - common noddy
  - Australian lesser noddy.
- shearwaters:
  - streaked shearwater
  - flesh-footed shearwater
  - wedge-tailed shearwater.
- terns:
  - Caspian tern
  - bridled tern
  - roseate tern
  - little tern
  - Australian fairy tern
  - crested tern.
- frigatebirds:
  - lesser frigatebird
  - great frigatebird
  - Christmas island frigatebird.
- tropicbirds:
  - white-tailed tropicbird
  - Christmas Island white-tailed tropicbird
  - red-tailed tropicbird.
- petrels:
  - southern giant-petrel
  - northern giant petrel
  - soft-plumaged petrel.
- albatrosses:
  - Amsterdam albatross
  - southern royal albatross
  - wandering albatross

    - Indian yellow-nosed albatross
    - Tasmanian shy albatross
    - white-capped albatross
    - Campbell albatross
    - black-browed albatross
    - white-capped albatross.
- boobies:
    - Abbott's booby
    - masked booby
    - brown booby
    - red-footed booby.
- ospreys.

Many of the seabird groups listed, such as noddies, terns, frigatebirds, tropicbirds and boobies above are typically found in tropical areas. These species may transiently occur within the Operational Area, however they are more likely to occur in the vicinity of offshore islands in the ZPI, such as Browse Island and Ashmore Reef, particularly during breeding seasons.

Many of the seabird groups listed above have temperate or sub-Antarctic distributions, such as shearwaters, petrels and albatrosses. These species are very unlikely to occur within the Operational Area, although may be present in the southern portion of the ZPI.

Migratory Shorebirds

Migratory shorebirds and wading birds include many species of birds that breed in northern Asia during the northern hemisphere summer (particularly eastern Russia and China) and migrate to Australasia during the southern hemisphere summer to feed. Many of these species follow the East Asian-Australasian flyway and are protected by migratory bird agreements between counties along this route, including Australia.

Migratory shorebirds typically do not nest within Australia, but do make extensive use of wetland and coastal habitats as feeding and resting areas during their migration. Several of these areas are listed under the Ramsar Convention and are protected under the EPBC Act (Section 7.2.5).

Migratory shorebirds that may occur within the Operational Area and ZPI include:

- sandpipers, curlews, stints, knots and turnstones (genus Calidris):
    - common sandpiper
    - sharp-tailed sandpiper
    - curlew sandpiper
    - pectoral sandpiper
    - broad-billed sandpiper
    - wood sandpiper
    - marsh sandpiper

  - Terek sandpiper
  - eastern curlew
  - whimbrel
  - ruddy turnstone
  - sanderling
  - ruff (reeve)
  - red-necked stint
  - red knot
  - great knot.
- shanks and tattlers:
  - grey-tailed tattler
  - common greenshank
  - common redshank.
- plovers:
  - double-banded plover
  - greater sand plover
  - lesser sand plover
  - oriental plover
  - pacific golden plover
  - grey plover.
- godwits:
  - bar-tailed godwit
  - bar-tailed godwit (baueri)
  - Northern Siberian bar-tailed godwit
  - Black-tailed godwit.
- Oriental Pratincole
- Asian Dowitcher
- Australian Painted-snipe.

Many of the species listed above are closely related and within the family Scolopacidae, and share very similar life histories. All of these migratory shorebird species may transit through the Operational Area during migration. They are likely to occur seasonally along coastlines, in estuaries and wetlands throughout the ZPI, particularly Ramsar sites (Section 7.2.5).

7.3 Socio-Economic Environment

7.3.1 Heritage

7.3.1.1 World Heritage Properties

There are no World Heritage properties within the Operational Area. Two World Heritage properties occur within the far southern portion of the ZPI:

- the Ningaloo Coast (approximately 1,283 km south of Prelude)
- Shark Bay, Western Australia (approximately 1,651 km south of Prelude).

The Ningaloo Coast

The Ningaloo Coast WHA includes North West Cape and the Muiron Islands, and was inscribed, under criteria (vii) and criteria (x) by the World Heritage Committee onto the World Heritage Register in June 2011. The statement of Outstanding Universal Value for the Ningaloo coast was based on the natural criteria and recognised the following:

- Criterion (vii): The landscapes and seascapes of the property are comprised of mostly intact and large-scale marine, coastal and terrestrial environments. The lush and colourful underwater scenery provides a stark and spectacular contrast with the arid and rugged land. The property supports rare and large aggregations of whale sharks (Rhincodon typus) along with important aggregations of other fish species and marine mammals. The aggregations in Ningaloo following the mass coral spawning and seasonal nutrient upwelling cause a peak in productivity that leads approximately 300-500 whale sharks to gather, making this the largest documented aggregation in the world.
- Criterion (x): In addition to the remarkable aggregations of whale sharks the Ningaloo Reef harbours a high marine diversity of more than 300 documented coral species, over 700 reef fish species, roughly 650 mollusc species, as well as around 600 crustacean species and more than 1000 species of marine algae. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area. On the ecotone, between tropical and temperate waters, the Ningaloo Coast hosts an unusual diversity of marine turtle species with an estimated 10,000 nests deposited along the coast annually.

The dominant feature of the Ningaloo Coast WHA is Ningaloo Reef, the largest fringing reef in Australia. Ningaloo Reef supports both tropical and temperate species of marine fauna and flora and more than 300 species of coral (Department of Conservation and Land Management 2005).

The Ningaloo Coast World Heritage Area is entirely overlapped by the Commonwealth Ningaloo Australian Marine Park and State Ningaloo Marine Park and Muiron Islands Marine Management Area; refer to Section 7.3.2 for further information on these marine protected areas.

Shark Bay, Western Australia

The Shark Bay World Heritage Area includes Bernier Island, Dorre Island and Dirk Hartog's landing site. Shark Bay was inscribed under all four natural criteria (criterion vii, viii, ix, and x) by the World Heritage Committee onto the World Heritage Register in 1991. The statement of Outstanding Universal Value for the Shark Bay WHA was based on natural criteria and recognised the following:

- Stromatolites, in the hypersaline Hamelin Pool, which represent the oldest form of life on earth and are comparable to living fossils.

- One of the few marine areas in the world dominated by carbonates not associated with reef building corals.
- One of the largest seagrass meadows in the world, covering 103,000 ha, with the most seagrass species recorded in one area.
- Marine fauna such as dugong, dolphins, sharks, rays, turtles, fish, and migratory seabirds which occur in great numbers.
- The hydrologic structure of Shark Bay, altered by the formation of the Faure Sill and a high evaporation, has produced a basin where marine waters are hypersaline (almost twice that of seawater) and contributed to extensive beaches consisting entirely of shells.
- The Wooramel Seagrass Bank is also of great geological interest due to the extensive deposit of limestone sands associated with the bank, formed by the precipitation of calcium carbonate from hypersaline waters.

The Shark Bay World Heritage Area is partially overlapped by the State Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve.

7.3.1.2 Commonwealth Heritage Places

The Commonwealth Heritage List is a list of Indigenous, historic and natural heritage places owned or controlled by the Australian Government. The Operational Area is not located in, or in the immediate surrounds of, any Commonwealth Heritage places. There are a number of Commonwealth Heritage Places within the ZPI. These are listed in Table 7-7, with a supporting summary of their key values as Commonwealth Heritage Places.

Table 7-7: Commonwealth Heritage Places within the ZPI

Commonwealth Heritage Place	Approximate Distance from Prelude (km)	Description
Scott Reef and surrounds	155	Scott Reef is considered regionally important for the following features: • high diversity of marine fauna, including corals, fish and marine invertebrates; • physical characteristics of the reefs create environmental conditions which are rare for shelf atolls, including clear deep oceanic water and large tidal ranges that provide a high physical energy input to the marine ecosystem; • high representation of species not found in coastal waters off WA and for the unusual nature of their fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific, as well as the reefs of the Indonesian region; and • important for scientific research and benchmark studies into long term geomorphological and reef formation processes due to the age of the reef and the documentation of its geophysical and physical environmental characteristics.
Ashmore Reef National Nature Reserve	162	The Ashmore Reef National Nature Reserve protects Ashmore Reef, a large platform reef with coral reefs, sand flats and three vegetated islands. Specific values of this site include: • breeding and foraging habitat for marine turtles

Commonwealth Heritage Place	Approximate Distance from Prelude (km)	Description
		• considered to have the world's greatest abundance and diversity of sea snakes • habitat for 569 species of fish, 255 species of corals and 433 species of mollusc, as well as species not previously recorded or rarely recorded in Australia • an important seabird rookery and provides an important staging/feeding area for many seabirds and migratory shorebirds (Environment Australia 2002) • breeding and feeding habitat for a small dugong population (< 50 individuals).
Mermaid Reef – Rowley Shoals	535	Mermaid Reef is one of three reef systems, located 30 – 40 km apart, which make up the Rowley Shoals. The shoal consists of a reef flat roughly 500 to 800 m wide, shallow back reefs and a large lagoon. The Rowley Shoals have been described as the most perfectly formed shelf atolls in Australian waters, and the clear, deep water and large tidal range of the atolls are considered rare environmental conditions for shoals. The specific values of Mermaid Reef include: • high diversity of marine reef fauna, including corals, fish and marine invertebrates • important area for sharks, marine turtles and toothed whales, dolphins, tuna and billfish • important resting and feeding site for migratory seabirds • regionally significant due to the presence of many species not found in inshore tropical waters of Northern Australia, and species that are close to their geographical ranges. Includes 216 species of fish, 39 species of mollusc and seven species of echinoderms • considered a genetic stepping stone between the Indonesian archipelago and reefs to the south.
Ningaloo Marine Area - Commonwealth Waters	1,304	The Ningaloo Marine Area – Commonwealth Waters lies within the Commonwealth waters section of the Ningaloo Coast World Heritage Property – refer to Section 7.3.1.1 World Heritage Properties for further information about the environmental values within the Ningaloo Marine Area – Commonwealth Waters.
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877	The HMAS Sydney II and HSK Kormoran Shipwreck Sites Commonwealth Heritage Place covers the historic wrecks that resulted from a battle during the Second World War. Both wrecks are located in over 2,000 m of water. The battle between HMAS Sydney and HSK Kormoran resulted in the largest single loss of life in Australian naval history.

7.3.1.3 National Heritage Places

The National Heritage List is Australia's list of natural, historic and Indigenous places of outstanding significance to the nation. There are no National Heritage properties in, or in the immediate surrounds of, the Operational Area. National Heritage Places in the ZPI are described in Table 7-8.

Table 7-8: National Heritage Places within the ZPI

National Heritage Place	Approximate Distance from Prelude (km)	Description
The West Kimberley	171	The West Kimberley is known for its ancient geology, Aboriginal culture, stunning landscapes, and biological richness. The West Kimberley coastline includes a range of landforms, including cliffs, rocky headlands, sandy beaches, rivers, waterfalls and numerous islands located off the coast. The West Kimberley holds extensive history of Aboriginal people who have lived in the area for at least 40,000 years. The West Kimberley also provides remnant habitats for many native animals and plants which are now absent elsewhere in Australia. Many of the national heritage values of the West Kimberley are located away from the coastline will not credibly be affected by the petroleum activities considered in this EP.
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves	1,097	Barrow Island and the Montebello / Barrow Islands Marine Conservation Reserves are of national and international significance as a diverse region of high conservation value terrestrial and aquatic habitats, and high species diversity and endemism. Barrow Island hosts a range of terrestrial and subterranean species that are unique, including species that are extinct, or threatened with extinction, on mainland Australia. The marine environment within the reserves has complex bathymetry with many reefs and a diverse assemblage of corals. Significant marine turtle nesting activity occurs on sandy beaches throughout the reserves, including significant flatback and green turtle rookeries.
The Ningaloo Coast	1,283	Refer to The Ningaloo Coast World Heritage Area description in Section 7.3.1.1 World Heritage Properties
Shark Bay, Western Australia	1,651	Refer to Shark Bay, Western Australia World Heritage Area description in Section 7.3.1.1 World Heritage Properties
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877	Refer to HMAS Sydney II and HSK Kormoran Shipwreck Sites description in Section 7.3.1.3 National Heritage Places

7.3.1.4 Cultural Heritage

There are no known sites of Indigenous or European cultural significance within the Operational Area. The Australian coastline and nearshore islands have a long history of Indigenous occupation and host many culturally significant sites. The ZPI partially overlaps parts of the Kimberley, Pilbara and Gascoyne coastlines, which host numerous culturally significant sites, including sites that contribute to the national heritage value of the West Kimberley National Heritage Place.

7.3.1.5 Underwater Cultural Heritage

Information on underwater cultural heritage, including historic shipwrecks, is maintained in the Australasian Underwater Cultural Heritage Database, a searchable database of records provided by the Australian DoEE. A search of the database revealed no known shipwrecks or other underwater cultural heritage sites within the Operational Area. The nearest historic shipwreck is the wreck of the sailing vessel Berteaux, which lies approximately 18 km south-east of the Prelude FLNG facility.

7.3.2 Marine Protected Areas

The Operational Area does not overlap any Marine Protected Areas (MPAs), such as Commonwealth Australian Marine Parks (AMPs) or state marine parks. There are a number of Commonwealth AMPs and Western Australian MPAs in the ZPI (Figure 7-10) Each of these MPAs is described in Table 7-9.

All AMPs and many state MPAs have management plans in place, which outline the objectives for the management of the protected area. These objectives have been considered where applicable in the environmental impact and risk assessment in Section 9.13.

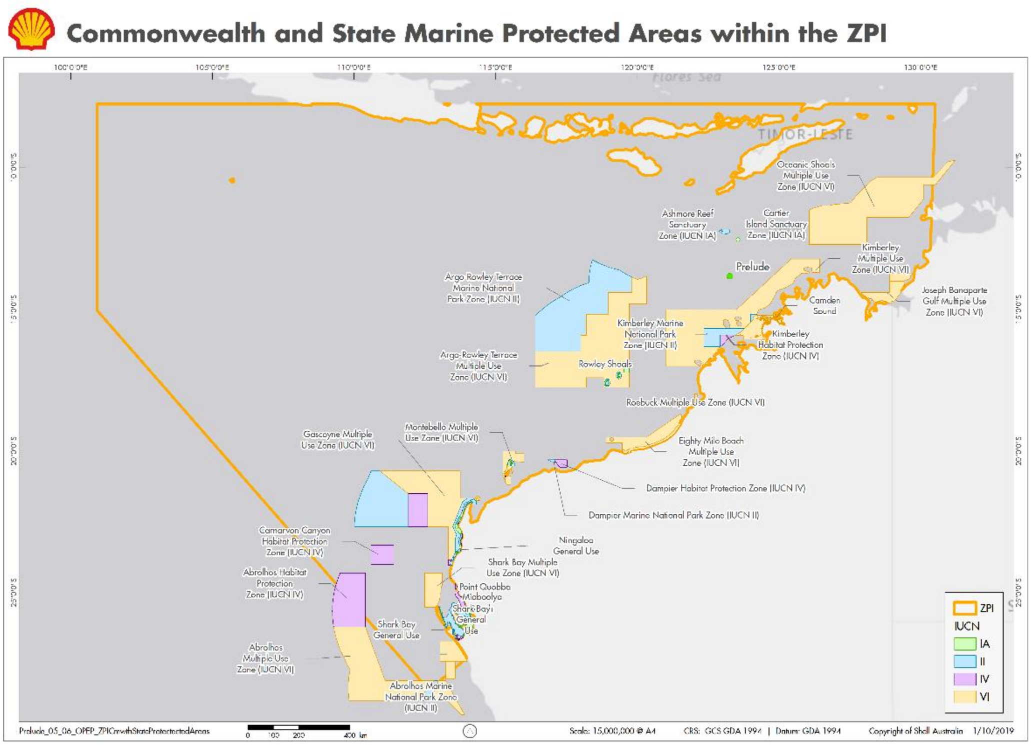

Figure 7-10: Commonwealth and State Marine Protected Areas within the ZPI

Table 7-9: MPAs within the ZPI

Marine Protected	Distance from Prelude (km)	Description
Commonwealth AMPs		
Kimberley	111	The Kimberley AMP covers approximately 74,469 km^2 and ranges in water depth from less than 15 m to approximately 800 m. The AMP lies from the Lacepede Islands in the north to the Holothuria Banks offshore from Cape Bougainville. The Kimberley AMP contains the following conservation values (Director of National Parks 2018a): • Important foraging areas for migratory seabirds, dugongs, dolphins and marine turtles • Important migration pathway and nursery areas for the humpback whale • Adjacent to important foraging and pupping areas for sawfish and important nesting sites for green turtles • Features such as the continental shelf, slope, plateau, pinnacles, terraces, banks and shoals and deep holes/valleys • Examples of the communities and seafloor habitats of the Northwest Shelf Transition, North West Shelf province and Timor Province provincial bioregions along with the Kimberley, Canning, Northwest Shelf and Oceanic Shoals meso-scale bioregions. The AMP provides protection for two KEFs; an ancient coastline (a unique seafloor feature that provides areas of enhanced productivity) and continental slope demersal fish communities (the second richest area for demersal fish species in Australia), refer to Section 7.2.3. The Kimberley meso-scale bioregion in particular has been reported to be one of the most diverse coral areas in WA. In addition, the reserve is adjacent to the listed West Kimberley National Heritage place and Western Australian Lalang-garram / Camden Sound Marine Park.
Cartier Island	134	Cartier Island AMP is considered to be a biodiversity hotspot (like nearby Ashmore Reef) and is thought to be a source of larvae of marine biota such as corals which are transported south by the Leeuwin Current. The AMP covers an area of approximately 172 km^2. Key conservation values include (Director of National Parks 2018a): • An unvegetated sand island • High diversity and abundance of hard and soft corals, gorgonians, sponges and a range of encrusting organisms • Algae and seagrasses • Important breeding and foraging habitat for seabirds • Foraging habitat for whale sharks • Nesting, inter-nesting and foraging habitat for marine turtles • High diversity and abundance of seasnakes.
Ashmore Reef	162	The Ashmore Reef AMP covers an area of 583 km^2 and is a designated Ramsar Wetland (Section 7.2.5). Key conservation values of the AMP include (Director of National Parks 2018a):

Marine Protected	Distance from Prelude (km)	Description
		• Regionally significant as contains ecosystems, habitat and communities representative of the NWS, Timor Province and emergent oceanic reefs • Biologically rich habitat including primary producer habitat (mangroves, seagrass beds and coral reefs) and their associated benthic communities, fishes and other biota • Regionally important nesting, inter-nesting, foraging areas for marine turtles (particularly green but also hawksbill and loggerhead turtles). An estimated 11,000 marine turtles feed in the area throughout the year • Isolated, small dugong population of less than 50 individuals that breeds and feeds around the reef. This population is thought to be genetically distinct from other Australian populations • Important seabird rookeries and staging points/feeding areas for migratory sea/shorebirds including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns • International significance for seasnake abundance and diversity • Importance cultural and heritage sites: Indonesian artefacts and grave sites.
Oceanic Shoals	321	The Oceanic Shoals AMP comprises a 71,743 km^2 area, with a large proportion (39,964 km^2) designated as Multiple Use Zone (IUCN Category VI). There are smaller areas designated for National Park Zone (Category II, 406 km^2), Habitat Protection Zone (Category IV, 6,929 km^2), and Special Purpose Zone for Trawling (Category VI, 10,461 km^2). The AMP has several conservation values (Director of National Parks 2018a): • important inter-nesting area for the flatback and olive ridley turtles • an important foraging area for loggerhead and olive ridley turtles • examples of the ecosystems of both the Northwest Shelf Transition and Timor Transition provinces. KEFs represented in the reserve are carbonate banks, pinnacles and the shelf break and slope of the Arafura Shelf. (Refer to Section 7.2.3.)
Argo-Rowley Terrace	323	The Argo-Rowley Terrace AMP covers 146,099 km^2 of the MPA network, including the Commonwealth waters surrounding the Rowley Shoals (each reef managed as separate state and Commonwealth marine parks). The Argo-Rowley Terrace Commonwealth Marine Park encompasses water depths from approximately 220–6000 m. The ecological and conservation values include (Director of National Parks 2018a): • Important foraging areas for migratory seabirds and, reportedly, the loggerhead turtle • Support for relatively large populations of sharks (compared with other areas in the region) • A range of seafloor features such as canyons, continental rise and the terrace, among others • Connectivity between the reefs of the Rowley Shoals

Marine Protected	Distance from Prelude (km)	Description
		• Linkage of the Argo Abyssal Plain with the Scott Plateau through canyons. The AMP is contiguous with the Western Australian Rowley Shoals Marine Park.
Roebuck	480	The Roebuck Marine Park is located approximately 12 km offshore of Broome, and is adjacent to the Western Australian Yawuru Nagulagun/Roebuck Bay Marine Park. The Marine Park covers an area of 304 km² and a water depth range of less than 15 m to 70 m. The ecological and conservation values include (Director of National Parks 2018a): • The park is adjacent to the Eighty Mile Beach Ramsar wetland • Representative ecosystems of the Northwest Shelf Province • Breeding and resting habitat for seabirds • foraging and inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat for dugong.
Mermaid Reef	523	The Mermaid Reef Commonwealth Marine Park encompasses Mermaid Reef and covers 540 km^2; it is classified as an IUCN protected area category 1a, Sanctuary Zone (Strict Nature Reserve). Mermaid Reef is one of the best geological examples of a shelf-edge reef in Australian waters (one of three oceanic reefs that form the Rowley Shoals). It is the only reef of the Rowley Shoals located entirely in Commonwealth waters. Mermaid Reef supports (Director of National Parks 2018a): • rich coral communities (216 species of hard coral, 12 genera of soft corals) • a high diversity of associated sessile and mobile invertebrates (echinoderms, molluscs and crustaceans) • more than 390 reef and pelagic fish species • a variety of sharks that frequent the reef habitats. The Mermaid Reef AMP also includes the Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals KEF (Table 7-1).
Joseph Bonaparte Gulf	604	The Joseph Bonaparte Gulf Marine Park is located approximately 15 km west of Wadeye, Northern Territory, and approximately 90 km north of Wyndham, Western Australia, in the Joseph Bonaparte Gulf. It is adjacent to the Western Australian North Kimberley Marine Park. The Marine Park covers an area of 8,597 km² and water depth ranges between less than 15 m and 100 m (Director of National Parks 2018b). Environmental values within the Park include (Director of National Parks 2018b): • species and communities associated with the Northwest Shelf Transition bioregion

Marine Protected	Distance from Prelude (km)	Description
		• carbonate bank and terrace system of the Sahul Shelf KEF • prominent shallow seafloor features, including emergent reef, shoals and sand banks • biologically important areas including foraging habitat or marine turtles and the Australian snubfin dolphin.
Eighty Mile Beach	788	Eighty Mile Beach AMP comprises a 10,785 km² Multiple Use Zone. Environmental values within the AMP include (Director of National Parks 2018a): • examples of ecosystems representative of the Northwest Shelf Province • diverse benthic and pelagic fish communities • and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales • a range of fauna threatened, migratory, marine and cetacean under the EPBC Act. The AMP is adjacent to the Eighty Mile Beach Ramsar wetland (which is beyond the ZPI).
Dampier	950	The Dampier Marine Park is located approximately 10 km north-east of Cape Lambert and 40 km from Dampier extending from the Western Australian state water boundary. The Marine Park covers an area of 1,252 km² and a water depth range between less than 15 m and 70 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems and communities of the Northwest Shelf Province • breeding and foraging habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales.
Montebello	1,047	The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western Australian state water boundary, and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks. The Marine Park covers an area of 3,413 km² and water depths from less than 15 m to 150 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • habitats, species and ecological communities associated with the Northwest Shelf Province • ancient coastline at the 125 m depth contour KEF • breeding habitat for seabirds • inter-nesting, foraging, mating and nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat for whale sharks.

Marine Protected	Distance from Prelude (km)	Description
Gascoyne	1,277	The Gascoyne Marine Park is located approximately 20 km off the west coast of the Cape Range Peninsula, adjacent to the Ningaloo Reef Marine Park and the Western Australian Ningaloo Marine Park, and extends to the limit of Australia's exclusive economic zone. The Marine Park covers an area of 81,766 km² and water depths between 15 m and 6,000 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • four KEFs: – canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula – Commonwealth waters adjacent to Ningaloo Reef – continental slope demersal fish communities – the Exmouth Plateau. • diverse continental slope habitats • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat and migratory pathway for pygmy blue whales.
Ningaloo	1,304	The Ningaloo Marine Park stretches approximately 300 km along the west coast of the Cape Range Peninsula, and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park. The Marine Park covers an area of 2,435 km² and a water depth range of 30 m to more than 500 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems of the: – Central Western Shelf Transition – Central Western Transition – Northwest Province – Northwest Shelf Province. • KEFs: – canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula – Commonwealth waters adjacent to Ningaloo Reef – continental slope demersal fish communities • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales • foraging habitat and migratory pathway for pygmy blue whales • breeding, calving, foraging and nursing habitat for dugong

Marine Protected	Distance from Prelude (km)	Description
		• foraging habitat for whale sharks.
Shark Bay	1,588	The Shark Bay Marine Park is located approximately 60 km offshore of Carnarvon, adjacent to the Shark Bay world heritage property and national heritage place. The Marine Park covers an area of 7,443 km², extending from the Western Australian state water boundary, and a water depth range between 15 m and 220 m (Director of National Parks 2018a). Environmental values within the Park include (Director of National Parks 2018b): • representative ecosystems of the Central Western Shelf and Central Western Transition bioregions • connectivity between deeper Commonwealth waters and inshore waters of Shark Bay • breeding habitat for seabirds • inter-nesting habitat for marine turtles • migratory pathway for humpback whales. The Park is adjacent to the Shark Bay World Heritage Area.
Abrolhos	1,781	The Abrolhos Marine Park is located adjacent to the Western Australian Houtman Abrolhos Islands, covering a large offshore area extending from the Western Australian state water boundary to the edge of Australia's exclusive economic zone. It is located approximately 27 km south-west of Geraldton and extends north to approximately 330 km west of Carnarvon. The northernmost part of the shelf component of the Marine Park, north of Kalbarri, is adjacent to the Shark Bay World Heritage Area. The Marine Park covers an area of 88,060 km² and a water depth range between less than 15 m and 6,000 m (Director of National Parks 2018c). Environmental values within the Park include (Director of National Parks 2018c): • KEFs: – Commonwealth marine environment surrounding the Houtman Abrolhos Islands – demersal slope and associated fish communities of the Central Western Province – mesoscale eddies – Perth Canyon and adjacent shelf break, and other west-coast canyons – western rock lobster – ancient coastline between 90 m and 120 m depth – Wallaby Saddle. • high biodiversity due to the southwards flowing Leeuwin Current supplying tropical species • foraging and breeding habitat for seabirds • foraging habitat for Australian sea lions and white sharks • migratory pathway for humpback and pygmy blue whales.

Marine Protected	Distance from Prelude (km)	Description
		The Marine Park is adjacent to the northernmost Australian sea lion breeding colony in Australia on the Houtman Abrolhos Islands.
Western Australian Marine Parks		
Lalang-garram / Camden Sound	182	The Lalang-garram / Camden Sound Marine Park provides protection for a large, biologically diverse part of the Kimberley coastal waters. The park is contiguous with the Commonwealth Kimberley AMP, which is described above. The environmental and social values within the park include: • habitat for a range of marine species, including marine turtles, coastal dolphins and dugong • important calving and resting areas for humpback whales • sanctuary zones which prohibit most activities, including fishing • important cultural heritage sites for the traditional owners. The Lalang-garram / Camden Sound Marine Park is jointly managed by WA government agencies and the traditional owners of the land.
North Kimberley	188	The North Kimberley Marine Park covers an area of approximately 1,845,000 hectares, which is currently zoned as IUCN Category VI – multiple use. The park is remote and contains a range of outstanding natural and cultural values, such as a complex coastline with many small islands and cultural heritage sites for Aboriginal saltwater people. The Marine Park contains habitats such as coral reefs, seagrasses and mangroves. Fauna include dugong, birds, marine turtles, fishes, cetaceans and saltwater crocodiles.
Rowley Shoals	567	The Rowley Shoals Marine Park protects two of the three oceanic shoals (Clerke Reef and Imperieuse Reef) that constitute the Rowley Shoals. The third shoal (Mermaid Reef) is protected by the Argo-Rowley Terrace AMP. The Rowley Shoals Marine Park is characterised by intertidal and subtidal coral reefs, with rich and diverse marine fauna and high water quality. The reefs within the park may act as a source of recruits for habitats further south, via the Leeuwin Current, and hence are considered to be regionally significant (MPRA 2007).
Eighty Mile Beach Marine Park	612	Eighty Mile Beach is an extensive stretch of remote and remarkable coastal country located between Port Hedland and Broome, stretching for some 220 km from Cape Missiessy to Cape Keraudren. The marine park includes Eighty Mile Beach, Cape Keraudren and the diverse marine environments west of Cape Keraudren to Mulla Down Creek. it is jointly managed with the traditional owners of the area (Department of Parks and Wildlife 2014). The marine park contains vast intertidal sand and mudflats that extend up to 4 km wide at low tide and provide a rich source of food for many species. Eighty Mile Beach is one of the world's most important feeding grounds for migratory shorebirds and is a major nesting site for flatback turtles, which are only found in northern Australia. Both are critical components of the Eighty Mile Beach Ramsar site, and the management plan seeks to maintain its ecological character (Department of Parks and Wildlife 2014).

Marine Protected	Distance from Prelude (km)	Description
		The Park is adjacent to the Commonwealth Eighty Mile Beach AMP.
Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area	1,097	The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area are jointly managed and cover a combined area of 1,770 km^2, located approximately 170 km from the Operational Area at the closest point. A sanctuary zone covers the entire 4,100 ha Barrow Island Marine Park. The Barrow Island Marine Management Area covers 114,500 ha and includes most of the waters surrounding Barrow Island and Lowendal Islands, except for the port areas around Barrow and Varanus Islands. Key conservation and environmental values within the reserves include (Department of Environment and Conservation 2007): • a complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, cliffs and rocky shores • pristine sediment and water quality, supporting a healthy marine ecosystem • undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals • important mangrove communities, particularly along the Montebello Islands, which are considered globally unique as they occur in offshore lagoons • extensive subtidal macroalgal and seagrass communities • important habitat for cetaceans and dugongs • nesting habitat for marine turtles • important feeding, staging and nesting areas for seabirds and migratory shorebirds • rich finfish fauna with at least 456 species • historical culture of the pearl oyster (Pinctada maxima) in the reserves produces some of the highest quality pearls in the world. These islands support significant colonies of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the biggest breeding population of roseate terns in Western Australia. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. The Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area is contiguous with the Montebello Commonwealth Marine Park.
Muiron Islands Marine Management Area and Ningaloo Marine Park	1,283	The Ningaloo Marine Park (State waters) was established in 1987 and stretches 300 m from the North West Cape to Red Bluff. It encompasses the State waters covering the Ningaloo Reef system and a 40 m strip along the upper shore. The Muiron Islands Marine Management Area is managed under the same management plan as for the Ningaloo State Marine Park (Department of Conservation and Land Management 2005). The Ningaloo Marine Park is part of the Ningaloo Coast WHA. Ecological and conservation values of the Ningaloo Marine Park and Muiron Islands are summarised below. The ecological and conservation values include (Department of Conservation and Land Management 2005): • Unique geomorphology, which has resulted in a high habitat and species diversity

Marine Protected	Distance from Prelude (km)	Description
		• High sediment and water quality • Subtidal and intertidal coral reef communities providing food, settlement substrate and shelter for marine flora and fauna • Filter feeding communities (sponge gardens) in the northern part of the North West Cape and the Muiron and Sunday Islands • Soft sediment communities found in deeper waters, characterised by a surface film of microorganisms that provide a rich source of food for invertebrates • Macroalgae and seagrass communities, which are an important primary producer providing habitat for vertebrate and invertebrate fauna • Diverse fish fauna (approximately 460 species) • Foreshores and nearshore reefs of the Ningaloo coast and Muiron/Sunday islands provide inter-nesting, nesting and hatchling habitat for several species of marine turtles including the loggerhead, green, flatback and hawksbill turtles • Whale sharks aggregate annually to feed in the waters around Ningaloo Reef • Nesting and foraging habitat for seabirds and shorebirds.
Shark Bay Marine Park	1,691	The Shark Bay Marine Park was gazetted in 1990 as an A Class Marine Park Reserve and encompasses and area of 7,487 km^2. The values of the Marine Park are consistent with those of the World Heritage Area, which are described in Section 7.3.1.1 World Heritage Properties.

7.3.3 Fishing Industry

7.3.3.1 Traditional Fishing

In 1974, Australia recognised access rights for traditional Indonesian fishers in shared waters to the north of Australia, granting long-term fishing rights in recognition of the long history of traditional Indonesian fishing in the area. A Memorandum of Understanding (MOU) between the Governments of Australia and Indonesia enables Indonesian traditional fishers to continue their customary practices. This area is known as the ‘MOU Box’ and the Operational Area lies within it.

This MoU box covers Scott Reef and surrounds, Seringapatam Reef, Browse Island, Ashmore Reef and Cartier Island, representing an area of approximately 50,000 km2. Trochus, sea cucumbers (holothurians), abalone, green snail, sponges, giant clams and finfish, including sharks, are targeted by the fishers. Given the shallow water target species, these traditional Indonesian fishermen are only likely to be found in deep water areas during transit to and from the reef locations.

7.3.3.2 Recreational Fishing

Currently, there are no known recreational fishing activities in the Operational Area as the site is too far from shore to be accessed by recreational fishermen in small boats. Even at relatively high speed (30 km/hour), it would take at least fifteen hours for a recreational boat to reach the project area from the nearest port of Broome.

Recreational fishing, particularly boat-based angling, occurs throughout the ZPI. Recreational angling is expected to be centred around access nodes, such as marinas and boat launching facilities, found at towns across the Kimberley region. Recreational anglers typically target demersal and pelagic fish species for consumption and sport.

7.3.3.3 Commonwealth Fisheries

Commonwealth fisheries that overlap the Operational Area and ZPI are described in Table 7-10.

Table 7-10: Commonwealth fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
North-west slope trawl fishery	0	The North West Slope Trawl Fishery extends from 114°E to 125°E, from the 200 m isobath to the outer limit of the Australian exclusive economic zone (EEZ). The fishery traditionally targets scampi and deep-water prawns. Fishing for scampi occurs over soft, muddy sediments or sandy habitats, typically at depths of 200–400 m using demersal trawl gear on the continental slope. Activity in the fishery commenced in 1985, peaking at 21 active vessels in 1986-87 (Woodhams and Bath 2017). There are currently very few licence holders active in the fishery and fishing activity has steadily declined since establishment of the fishery. Two vessels operated in the fishery in the 2016-17 season, which is the same as the 2015-16 season. The total area of waters fished in 2016-17 did not include the Operational Area.
Southern bluefin tuna fishery	0	The Southern Bluefin Tuna Fishery is not active within Operational Area or the ZPI; all activity in this fishery occurs well south of the ZPI, primarily off South Australia. As such, the Southern Bluefin Tuna Fishery is not discussed further.
Western tuna and billfish fishery	0	The West Tuna and Billfish Fishery is currently active, running throughout the year. The fishery zoning extends to the Australian EEZ boundary in the Indian Ocean, overlapping the Operational Area. The fishery targets four pelagic species, which are all highly mobile: • broadbill swordfish (*Xiphias gladius*) • bigeye tuna (*Thunnus obesus*) • yellowfin tuna (*T. albacares*) • albacore tuna (*T. alalunga*). The methods used by the fishery are mainly pelagic longline and some minor-line. The number of vessels operating in the fishery has declined in recent years, with less than five vessels operating in the fishery since 2005 (Williams et al. 2017). Effort data shows fishing effort is concentrated off south-west Western Australia and South Australia (Williams et al. 2017).
Skipjack fishery	0	The combined western and eastern skipjack tuna (*Katsuwonus pelamis*) fisheries encompass the entire EEZ, including the Operational Area. The target species has historically been used for canning, and with the closure of canneries at Eden and Port Lincoln effort in the fishery has declined and there have been no active vessels operating since 2009 (Patterson & Bath 2017).

		Given the fishery has been inactive for a number of years and given the distribution of fishing effort when the fishery was active, fishing for skipjack tuna in the Operational Area is highly unlikely. Should the fishery commence efforts in the area in the future, fishing effort in the Operational Area is unlikely given the historical fishery was concentrated off southern Australia.
Northern prawn fishery	395	The Northern Prawn Fishery is located off Australia's northern coast from Cape York, Queensland to Cape Londonderry, Western Australia. It is Australia's second most valuable Commonwealth fishery. The fishery targets six species of prawn: • Red-legged banana prawn (*Penaeus indicus* and *P. merguiensis*) • White banana prawn (*Fenneropenaeus merguiensis*) • Brown tiger prawn (*P. esculentus*) • Grooved tiger prawn (*P. semisulcatus*) • Blue endeavour prawn (*Metapenaeus endeavouri*) • Red endeavour prawn (*M. ensis*). The fishery method is bottom trawling during two seasons – April to June and August to November, with the season end dates depending on the catch rates. In 2017, there were 52 vessels with fishing rights, which is the maximum number of vessels active at one time. The Northern Prawn Fishery management area is located approximately 433 km from the Operational Area.
Western deepwater trawl fishery	1,072	The Western Deepwater Trawl Fishery is permitted to operate only in deep waters from the 200 m isobath, as far north as the North West Cape. This fishery targets a number of deep water demersal finfish and crustacean species. The nominated fishing grounds are extensive. However, most of the fishing effort is south and offshore of the North West Cape, with areas of medium and high-density fishing activity located to the south of Ningaloo Reef and west of Shark Bay. No vessels were active in the fishery in 2014-15 or 2015-16 seasons (Woodhams and Bath 2017).

7.3.3.4 Western Australian Managed Fisheries

State-based Western Australian commercial fisheries that overlap the ZPI are described in Table 7-11.

Table 7-11: Western Australia fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
Mackerel Fishery	0	The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*) using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*) (Molony et al. 2015). The commercial fishery extends from Geraldton to the Northern Territory border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3). The majority of the catch is taken from waters off the Kimberley coasts (Lewis and Jones 2017), reflecting the tropical distribution of mackerel species (Molony et al. 2015). The majority of fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area, with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development prior to spawning (Mackie et al. 2003).
West Coast Deep Sea Crustacean	0	The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the WA/NT border in water depths great than 150 m within the Australian Fishing Zone, including the Operational Area. The fishery targets deep water crustaceans, with the vast majority (>99%) of the catch landed in 2015 comprised of crystal crabs (How and Yerman 2017). Two vessels operated in the fishery in 2015, using baited pots operated in a longline formation in the shelf edge waters mostly in depths between 500 and 800 m (How and Yerman 2017). Fishing effort was concentrated between Fremantle and Carnarvon.
South West Coast Salmon	0	The South West Coast Salmon Managed Fishery operates on various beaches south of the metropolitan area and includes all Western Australian waters north of Cape Beaufort except Geographe Bay. No fishing takes place north of the Perth metropolitan area (well beyond the ZPI), despite the managed fishery boundary extending to Cape Beaufort (Western Australia / Northern Territory border).
Northern Demersal Scalefish	0	The Northern Demersal Scalefish Managed Fishery operates off the northwest coast of Western Australia in the waters east of 120°E longitude. The permitted means of operation within the fishery include handline, dropline and fish traps; since

Fishery Name	Distance from Prelude (km)	Description
		2002 it has essentially been a trap-based fishery. Gear restrictions and spatial zones as the primary management measures. The main species landed by this fishery are red emperor and goldband snapper (Newman et al. 2017b). In 2015, there were 7 vessels with fishing rights (Newman et al. 2017b). The Northern Demersal Scalefish Managed Fishery overlaps the Operational Area.
Marine Aquarium and Specimen Shell	28	The Marine Aquarium and Specimen Shell managed fisheries are largely diver-based, with effort concentrated around the Capes region, Perth, Geraldton, Exmouth and Dampier. Effort in these fisheries is relatively low and spread over a large geographic area. Given the nature of the fisheries, effort is expected to be largely restricted to coastal waters < 30 m water depth.
Abalone	28	The Western Australian abalone fishery includes all coastal waters from the Western Australian and South Australian border to the Western Australian and Northern Territory border. The fishery is concentrated on the south coast (greenlip and brownlip abalone) and the west coast (Roe's abalone). Abalone are harvested by divers, limiting the fishery to shallow waters (typically < 30 m). No commercial fishing for abalone north of Moore River (zone 8 of the managed fishery) has taken place since 2011/2012 (Strain et al. 2017).
Broome Prawn	28	The Broome Prawn Managed Fishery is one of the four northern managed prawn fisheries (the others are the Kimberley, Nickol Bay and Onslow prawn managed fisheries). It is the least active of these four fisheries, with 0.3 tonnes of western king prawns and 0.8 tonnes of coral prawns landed in 2015 (Sporer et al. 2017). The extent of the Broome Prawn Managed Fishery is approximately 28 km from the Operational Area.
Kimberley Prawn	47	The Kimberley Prawn Managed Fishery operates between Koolan Island and Cape Londonderry. Its target catch is banana prawns (*Penaeus merguiensis*) but also catches tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and western king prawns (*Penaeus latisulcatus*). Landings in 2016 (Sporer et al. 2017) season were 155 tonnes. The catch season is from early April to late November. The extent of the Kimberley Prawn Managed Fishery is located approximately 47 km from the Operational Area.
Kimberley Gillnet and Barramundi	213	The limited entry Kimberley Gillnet and Barramundi Fishery operates from the Western Australian/Northern Territory border to the northern end of Eighty Mile Beach in the nearshore and estuarine zones. The managed fishery boundary extends approximately 3 nm from the shoreline. In 2013, six vessels fished in the Kimberley Gillnet and Barramundi Fishery. The fishery targets barramundi (*Lates calcarifer*), blue threadfin (*Polydactylus macrochir*) and king threadfin (*Eleutheronema*

Fishery Name	Distance from Prelude (km)	Description
		tetradactylum) (Newman et al. 2017a). The extent of the fishery is located approximately 213 km to the east (near to the shoreline) of the Operational Area.
Pearl Oyster Fishery	0	The Western Australian Pearl Oyster Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. Pearl oysters (Pinctada maxima) are collected by divers in shallow coastal waters along the Northwest Shelf and Kimberley, which are mainly for use in the culture of pearls. The fishery is separated into four management zones; the Prelude FLNG facility lies within management zone 3, however the Operational Area is much deeper than safe diving depths in which pearl oyster fishing occurs. Most pearl fishing occurs in inner continental shelf waters (< 30 m) along the Kimberley and Pilbara coastlines. Given the fishery is diver-based (i.e. restricted to safe diving depths) interaction with fishery participants from the operation of the Prelude FLNG facility are very unlikely.
Pilbara Trap	477	The Pilbara Trap Managed Fishery is one of three fisheries (Pilbara Fish Trawl (Interim) Managed Fishery, Pilbara Line Fishery) that make up the Pilbara Demersal Scalefish Fisheries. The main species that are caught in this subregion are bluespotted emperor (*Anax nigrofasciatus*), red emperor (*Lutjanus seba)* and rankin cod (*Epinephelus multinotatus*). There are six licences in the Pilbara Trap Managed Fishery that are operated across three vessels. Fishing in this area is not restricted by seasons. The extent of the Pilbara Trap Managed Fishery is located approximately 477 km south-west of the Operational Area.
Pilbara Fish Trawl	560	The Pilbara Fish Trawl (Interim) Managed Fishery is one of three fisheries (Pilbara Trap Managed Fishery and Pilbara Line Fishery) that make up the Pilbara Demersal Scalefish Fisheries. The main species that are caught in this subregion are bluespotted emperor (*Anax nigrofasciatus*), red emperor (*Lutjanus seba)* and rankin cod (*Epinephelus multinotatus*). The fishery is restricted to less than approximately 2% of the North West Shelf. The trawling method uses a single net with extension sweeps. The extent of the Pilbara Fish Trawl (Interim) Managed Fishery is located approximately 560 km south-west of the Operational Area.
Nickol Bay Prawn	560	The Nickol Bay Prawn Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. Landings in the fishery in 2015 were approximately 87 tonnes, comprised largely of banana prawns (Sporer et al. 2017). The annual landing in 2015 was approximately 87 tonnes. The catch effort from the 2016 season was 17 tonnes. The extent of the Nickol Bay Prawn Managed Fishery is approximately 560 km from the Operational Area.

Fishery Name	Distance from Prelude (km)	Description
Onslow Prawn	920	The Onslow Prawn Managed Fishery is one of five prawn fisheries that are collectively referred to as the North Coast Prawn Managed Fisheries. The North Coast Prawn Managed Fisheries produced approximately 200-300 t annually. These fisheries all use low opening, otter prawn trawl systems. The catch effort from the 2016 season was negligible; only one boat fished in the Onslow Prawn Managed Fishery area in 2016. The extent of the fishery is located approximately 920 km south-west of the Operational Area.
Exmouth Gulf Prawn	1,263	The Exmouth Gulf Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear within Exmouth Gulf. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. The fishery is of high value, with approximately 1,067 tonnes landed in 2015, with the town of Exmouth the main port for participants in the fishery. The fishery is managed based on input controls, temporal closures and spatial closures (Kangas et al. 2017c).
West Coast Rock Lobster	1,272	The West Coast Rock Lobster Fishery targets the western rock lobster (*Panulirus cygnus*) from Shark Bay south to Cape Leeuwin using baited traps (pots). In 2008, it was determined that the allocated shares of the West Coast Rock Lobster resource would be 95% for the commercial sector, 5% to the recreational sector, and one tonne to customary fishers. The commercial fishery has been Australia's most valuable single-species wild capture fishery. In 2010/2011, the fishery moved to an individually transferable quota fishery. The fishery is managed using zones, seasons and total allowable catch. Landings in 2015 were 6,416 tonnes (de Lestang and Rossbach 2017).
Gascoyne Demersal Scalefish	1,470	The Gascoyne Demersal Scalefish Fishery comprises commercial and recreational fishing for demersal scalefish in the continental waters of the Gascoyne Coast Bioregion. The fishery is located between the southern Ningaloo coast to south of Shark Bay with a closure area from Point Maud to Tantabiddi. Commercial vessels have traditionally targeted the oceanic stocks of pink snapper (*Pagrus auratus*) during the winter months (fishing spawning aggregations in peak season of June to July). The present fishery also targets other demersal species including the goldband snapper (*Pristipomoides* spp.), red emperor (*Lutjanus sebae*), other emperors and cod.
Shark Bay Scallop	1,512	The Shark Bay Scallop Managed Fishery targets saucer scallops (*Ylistrum balloti*) using otter trawls. The stock is currently recovering after sustained poor recruitment since 2010 (Kangas et al. 2017a). Annual catches in the fishery are highly variable due to recruitment. Scallops occur on sandy and muddy sediments, which may also host commercially exploited prawns; a number of vessels participate in both the Shark Bay Scallop Managed Fishery and the Shark Bay Prawn Managed Fishery (Kangas et al. 2017a).

Fishery Name	Distance from Prelude (km)	Description
Shark Bay Prawn	1,512	The Shark Bay Prawn Managed Fishery is the highest producing Western Australian fishery for prawns. It targets the western king prawn (*Penaeus latisulcatus*) and brown tiger prawn (*P. esculentus*) and takes a variety of smaller prawn species including endeavour prawns (*Metapenaeus* spp.) and coral prawns (various species). Prawns are caught using otter trawls over sandy or muddy substrates, with over 2,000 tonnes landed in 2015 (Kangas et al. 2017b). A number of vessels active in the Shark Bay Prawn Managed Fishery also fish in the Shark Bay Scallop Managed Fishery.
Shark Bay Crab	1,670	The blue swimmer crab (*Portunus armatus*) resource in Shark Bay is harvested commercially by the Shark Bay crab trap, prawn trawl and scallop trawl fisheries. Commercial fishing for blue swimmer crabs in Shark Bay was voluntarily halted by industry in April 2012 to facilitate stock rebuilding. The fishery was reopened in 2013/14, with a 450 tonne catch limit instituted for the 2015 season.
Shark Bay Beach Seine and Mesh Net	1,685	The Shark Bay Seine and Mesh Net Managed Fishery operates from Denham and used a combination of beach seine and mesh net gears to mainly take four species/groups including whiting (mostly yellowfin with some goldenline), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus morrisoni*). This fishery is managed by limited entry, gear restrictions (e.g. vessel size, net length and mesh size) and permanently closed waters (e.g. Hamelin Pool, Big Lagoon, Denham foreshore).
West Coast Demersal Scalefish	1,765	The West Coast Demersal Scalefish Fishery comprises inshore and offshore suites of demersal scalefish species that are exploited by different commercial fisheries, recreational and charter fishers operating in the West Coast Bioregion. The West Coast Inshore Demersal suite occurs in waters < 250 m deep and is comprised of approximately 100 different species, the most important of which are West Australian dhufish (*Glaucosoma hebraicum*) and pink snapper (*Pagrus auratus*). Less important species include redthroat emperor (*Lethrinus miniatus*), bight redfish (*Centroberyx gerrardi*) and baldchin groper (*Choerodon rubescens*). The West Coast Offshore Demersal suite occurs in waters < 250 m deep and includes eightbar groper (*Hyporthodus octofasciatus*), hapuka (*Polyprion oxygeneios*), blue-eye trevalla (*Hyperoglyphe antactica*) and ruby snapper (*Etelis carbunculus*). Access to the fishery is limited. Gear and other restrictions apply in the form of maximum number of lines and hooks and arrangements regulating the carriage of lines and fish.

7.3.3.5 Northern Territory Managed Fisheries

Northern Territory-based commercial fisheries that overlap the ZPI are described in Table 7-12.

Table 7-12: Northern Territory fisheries within the ZPI

Fishery Name	Distance from Prelude (km)	Description
Aquarium Fishery	537	The Northern Territory Aquarium Fishery targets a range of marine, estuarine and freshwater species for the aquarium trade, including finfish (e.g. freshwater rainbowfish), invertebrates (e.g. hermit crabs) and plants. Fishing is typically either from boat or shore by diving, nets and hand collection. These methods restrict fishing activity in shallow coastal, estuarine and riverine waters. There are approximately 11 licences and three boats active in the fishery each year. The managed fishery area extends to the edge of the Australian fishing zone (200 NM from the coast) and is partially overlapped by the ZPI. Given activity in the fishery is restricted to coastal waters, the operation of the Prelude FLNG facility is unlikely to impact upon the fishery.
Offshore Net and Line Fishery	537	The Offshore Net and Line Fishery covers an area of over 522,000 km^2 and extends from the NT high water mark to the boundary of the Australian fishing zone (NT Government 2017). The fishery permits both pelagic gillnets and longline gear and targets Australian and common blacktip sharks, spottail sharks and grey mackerel; however, longlines have not been used since 2013 due to a drop in shark fin price (NT Government 2017). The majority of the fishing effort is in the coastal zone (within 12 NM of the coast) and immediately offshore in the Gulf of Carpentaria (NT Government 2017). Effort beyond 12 NM from shore is typically very low The number of licences for the fishery is restricted to 17 and generally 11 licences are active in any given year (NT Government 2017).
Spanish Mackerel Fishery	537	The fishery extends from the NT high water mark to the outer limit of the Australian fishing zone (NT Government 2017). The fishery employs troll lines, floating handlines and rods. The majority of the fishing effort occurs in the vicinity of reefs, headlands and shoals and includes waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands (NT Government 2017). The target species of the fishery is the narrow-barred Spanish mackerel, however a small number of other mackerels are also taken.

Fishery Name	Distance from Prelude (km)	Description
Demersal Fishery	540	The Demersal Fishery boundary extends from 15 nautical miles from the NT coastal waters mark to the outer limit of the Australian fishing zone, excluding the area of the Timor Reef Fishery. The fishery employs trawl, hand and drop lines, and trap fishing methods. The main target species of the fishery are red snappers, goldband snappers, saddletail, and crimson snapper. There are currently 18 licences issued for the fishery (NT Government 2017).
Timor Reef Fishery	569	The Timor Reef Fishery operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km north-west of Darwin. The fishery extends north-west of Darwin to the WA-NT border and to the outer limit of the AFZ and covers an area of ~28,811 km^2 (NT Government 2017). The target species is goldband snapper, with other tropical snappers such as crimson snapper and saddletail snapper also consisting part of the catch. The majority of the fishing effort is undertaken using drop-lines and occurs primarily in the 100 – 200 m depth range.
Pearl Oyster Fishery	537	The Northern Territory pearl oyster fishery is currently a small diver-based fishery collecting pearl shell for mother-of-pearl. Most pearl oysters used in aquaculture in the Northern Territory are reared from hatchery stock, which are grown at farms locations are in waters around Darwin and East Arnhem Land (beyond the ZPI). Fishing for pearl oysters is diver-based, with five licences currently issued to fishers. The managed fishery area extends from the Australian coastline to the edge of the Australian fishing zone. As the fishery is diver-based, fishing activity is likely to be restricted to occupational diving depths (< 30 m). Hence, fishing activity may only occur in a very limited part of the managed fishery area. Given activity in the fishery is restricted to coastal waters, the operation of the Prelude FLNG facility is unlikely to impact upon the fishery.
Coastal Line Fishery	618	The Coastal Line fishery extends 15 nautical miles from the low water mark around the entire NT coastline. The fishery is divided into two zones, which divide the coastline at Vashon Head on the Cobourg Peninsula (NT Government 2017). The majority of fishing effort is focused around rocky reefs within 150 km of Darwin where Black Jewfish are targeted using mainly hook and line gear (NT Government 2017). Fish traps and droplines are also permitted beyond 2 NM from the coastline in the Eastern Zone of the fishery, and gillnets with a maximum drop of 5 m are also permitted (NT Government 2017). Catch from droplines and traps account for less than 7% of the total reported catch (NT Government 2017).

7.3.3.6 Aquaculture

There are no aquaculture operations within the Operational Area; aquaculture is typically restricted to shallow coastal waters. Aquaculture in the region consists primarily of culturing hatchery reared and wild caught oysters (*Pinctada maxima*) for pearl production, which is primary centred around Broome and the Dampier Peninsula. Leases typically occur in shallow coastal waters at depths of less than 20 m (Fletcher et al. 2006).

7.3.4 Tourism and Recreation

No tourism activities are known to occur within the Operational Area, but tourism activities occur widely in the ZPI. Most tourism in the ZPI is nature-based and hence is typically associated with outstanding natural features such as the Kimberley coastline and the offshore reefs and islands (e.g. Rowley Shoals). The remoteness of the region results in most offshore tourism activities being conducted from organised expeditions based on larger vessels.

Tourism makes a significant contribution to the regional economy, with the town of Broome (beyond the ZPI) providing a central node for many tourism-related activities in the region.

7.3.5 Defence

There are no defence exercise areas within the Operational Area or the ZPI, but defence activities may occur within the ZPI.

7.3.6 Shipping

Shipping activity in the vicinity of the Operational Area is considered high. However, almost all vessel activities in the Operational Area are associated with the operation of the Prelude FLNG facility and Ichthys facilities (e.g. offtake tankers, support vessels etc.).

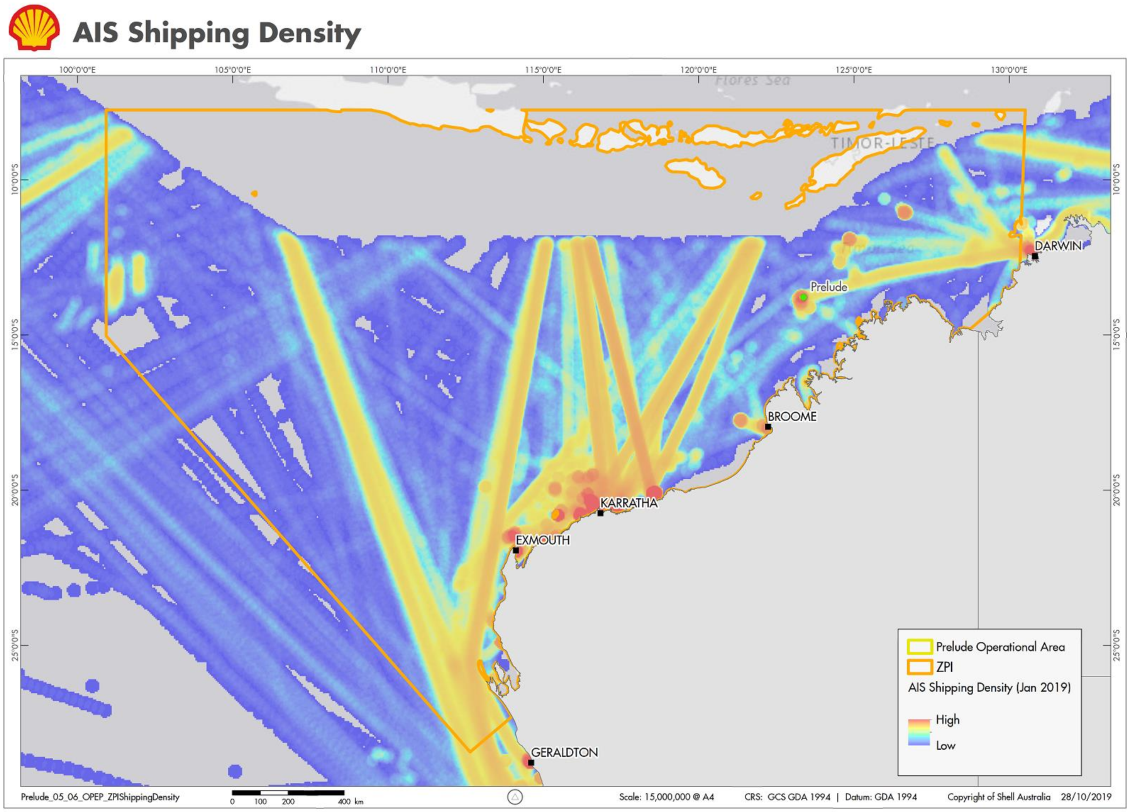

Figure 7-11: Shipping levels within the operational area and broader ZPI

7.3.7 Indonesian Coastline

The Indonesian is located over 300 km north of the Operational Area at the closest point, near the limits of the ZPI.

Indonesia is the world's largest archipelagic state and Indonesian waters play an important role in the global water mass transport system (Asian Development Bank ADB] et al. 2014). Indonesia has some of the most biologically rich coral reefs in the world with over 590 coral species having been identified. Coastal reefs are a primary source of food and income for coastal communities, as well as forming an integral part of the countries tourism industry (ADB et al. 2014). Coastal areas also support aquaculture production of algae, finfish and crustaceans. In addition to coral reefs, coastal habitats include sandy beaches, rocky shorelines, seagrass meadows, and mangroves.

7.3.8 Oil and Gas Industry

Oil exploration activities in the Timor Sea commenced in the late 1960s. Since this time numerous wells have been drilled throughout the region. Petroleum exploration has been active in the Browse Basin since the 1980s, with several commercial discoveries since that time. It is expected that petroleum exploration and development activities will continue in the region into the future.

There are several operating petroleum production facilities in the vicinity of the Prelude FLNG facility. The Ichthys facilities are the closest, situated approximately 20 km south of the Operational Area. The Montara facility is located approximately 188 km north-east of the Operational Area.

8.0 Acceptable Levels of Impact and Risk for the Petroleum Activities

The OPGGS (E) Regulations require the titleholder include an evaluation of all the impacts and risks that determined whether these will be of an 'acceptable' or 'unacceptable' level. To this end, Shell has determined acceptable levels of impact to the environmental receptors that may credibly be impacted by the petroleum activities considered within this EP. The process by which Shell has determined the acceptability of risks and impacts is detailed below.

8.1 Considerations in Developing Defined Acceptable Levels of Impact and Risk

Shell has established defined acceptable levels of impacts and risks for the petroleum activities considered in this EP relating to all the environmental receptors that were identified as being credibly impacted, or at risk of being impacted. The outcomes of the evaluation of environmental impacts and risks were assessed against these defined acceptable levels to determine if the impacts or risks were acceptable.

The following were considered when establishing the acceptable levels of impacts and risks:

- The principles of Ecologically Sustainable Development (ESD)
- Other requirements applicable to the Prelude project (e.g. laws, policies, standards, conventions etc.)
- Significant impacts[5] to MNES
- Internal context
- External context.

Each of these considerations are elaborated on below.

8.1.1 Principles of Ecologically Sustainable Development

Shell has considered the principles of ESD in defining acceptable levels of impacts and risks, as defined in Section 3A of the EPBC Act. The principles of ESD are summarised as:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

[5] Significant impacts refer specifically to the levels of impacts defined in the Matters of National Environmental Significance - Significant impact guidelines 1.1. Any subsequent reference in this EP to significant impacts refers to these levels unless stated otherwise.

- The principles of inter-generational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- Improved valuation, pricing and incentive mechanisms should be promoted.

8.1.2 Other Relevant Requirements

Shell considered other relevant requirements that apply to the environmental management of the petroleum activities considered in this EP, including legislation, policies, standards and guidelines in establishing acceptable levels of impacts and risks. (Refer to Section 3.0.)

8.1.3 Significant impacts to MNES

Given this EP forms the basis for NOPSEMA's assessment of matters protected under Part 3 of the EPBC Act in Commonwealth waters, Shell has given specific attention to the acceptability of impacts and risks to MNES. Where a potential interaction between the relevant MNES and an aspect of the petroleum activities covered by this EP was identified, the criteria provided are listed in Table 8-1.

Potential impacts and risks to MNES from aspects of the petroleum activities were deemed inherently acceptable if:

- The significant impact criteria in relation to the MNES are not anticipated to be exceeded
- The management of the aspect is aligned with published guidance material from the DoEE, including threat abatement plans, recovery plans and conservation advice.

Additionally, the Prelude FLNG project was assessed under the EPBC Act as an Environmental Impact Statement; and a series of conditions were applied to the project as a result of this assessment. These conditions are summarised in Table 3-2 which includes cross-references to the relevant sections within the EP and supporting documentation demonstrating how the requirements have been met.

Table 8-1: MNES Significant impact criteria applied to the petroleum activities considered in this EP

Category	Significant Impact Criteria
Listed Critically Endangered and Endangered species	An action is likely to have a significant impact on critically endangered or endangered species if there is likelihood that it will: • Lead to a long-term decrease in the size of a population • Reduce the area of occupancy of the species • Fragment an existing population • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • Introduce disease that may cause the species to decline, or interfere with the recovery of the species.

Listed Vulnerable Species	An action is likely to have a significant impact on vulnerable species if there is a likelihood that it will: • Lead to a long-term decrease in the size of an important population • Reduce the area of occupancy of and important population • Fragment an existing important population into two or more populations • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • Introduce disease that may cause the species to decline • Interfere substantially with the recovery of the species.
Listed Migratory Species	An action is likely to have a significant impact on migratory species if there is likelihood that it will: • Substantially modify, destroy or isolate an area of important habitat for a migratory species • Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species • Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.
Wetlands of International Importance	An action is likely to have a significant impact on a wetland of international importance if there is likelihood that it will result in: • Areas of wetland being destroyed or substantially modified • A substantial and measurable change in the hydrological regime of the wetland • The habitat or lifecycle of native species dependent upon the wetland being seriously affected • A substantial and measurable change in the water quality of the wetland which may adversely impact on the biodiversity, ecological integrity, social amenity or human health • An invasive species that is harmful to the ecological character of the wetland being established in the wetland.
Commonwealth Marine Area	An action is likely to have a significant impact on the environment in a Commonwealth Marine Area if there is likelihood that it will: • Result in a known or potential pest species becoming established in the Commonwealth marine area • Modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity on a Commonwealth marine area results • Have a substantial adverse effect on a population of a marine species or cetacean including its life cycle and spatial distribution • Result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological integrity[6], social amenity or human health • Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment

[6] In the context of the Prelude FLNG, a change to ecological integrity is considered to take into account broadscale, long term impacts to the ecosystem. With regards to the Commonwealth marine environment, the operational area is located in open offshore waters and the seabed is generally characterised by soft sediments. These characteristics are typical of the offshore Browse Basin."

	such that biodiversity, ecological integrity[2], social amenity or human health may be adversely affected • Have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.

8.1.4 Internal Context

Shell considered its internal requirements when establishing acceptable levels of impacts and risks. This context included Shell's environment policy, environmental risk management framework, internal standards, procedures, technical guidance material and opinions of internal stakeholders.

The following outlines Shell's internal impact and risk assessment defined acceptable levels:

- Residual planned impacts that are ranked as minor or less (i.e. minor, slight, no effect or positive effect) and residual risks for unplanned events ranked light or dark blue, are inherently 'acceptable', if they meet legislative and Shell requirements and the established acceptable levels of impacts and risks.
- Moderate residual impacts, and yellow and red residual risks, are 'acceptable' with appropriate controls in place and if good industry practice can be demonstrated.
- Major and massive residual impacts from planned activities, and massive residual risks from unplanned activities, are 'unacceptable'. The activity (or element of) should not be undertaken as the impact or risk is serious and does not meet the principles of ESD, legal requirements, Shell requirements or regulator and stakeholder expectations. The activity requires further assessment to reduce the risk to an acceptable level.

Table 8-2 provides a summary of the acceptability statements, as correlated to the rankings presented in the environmental impact and risk assessments in Section 9.0

Table 8-2: Acceptability Categories

Acceptability Statement	Residual Impact (Planned)	Residual Risk (Unplanned)
Inherently acceptable - Manage for continuous improvement through effective implementation of the HSSE and SP management system	• Positive Impact Consequence • No Impact Consequence • Slight Impact Consequence • Minor Impact Consequence	• Light Blue • Dark Blue
Acceptable with controls - Apply the hierarchy of control to reduce the risks to ALARP	• Moderate Impact Consequence	• Yellow • Red
Unacceptable	• Major Impact Consequence • Massive Impact Consequence	• Red - X

8.1.5 External Content

Shell also considered the external context when establishing acceptable levels of impacts and risks. This includes information provided by stakeholders during the preparation of the EP and the Prelude FLNG EIS. Shell routinely implements an ongoing stakeholder engagement program managed by Shell's external relations team. Reference is made to Section 5.0 for further information on the stakeholder engagement process and a summary of responses and objections/claims made by Relevant Persons is included in Table 5-3 and Table 5-4 which have informed the defined acceptable levels of impact.

Defined Acceptable Levels of Impact and Risk

The acceptable levels of impacts and risks to environmental receptors from the petroleum activities considered in this EP are summarised in Table 5-5.

Table 8-3: Summary of acceptable levels of impact for environmental receptors that may be affected by the petroleum activities considered in this EP

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
Physical Environment	**Water quality**	Limited environmental impact to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Routine planned liquid discharges from Prelude FLNG facility, considered as the larger impact footprint compared to support vessels, may result in localized water quality impacts in the immediate vicinity. Modelling studies indicate the impacts will be localised around the FLNG facility which is characterised as open offshore waters, typical of and well represented within the Browse Basin.
	Sediment quality	Limited environmental impact to sediment quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	The liquid discharges from the FLNG facility (e.g. PFW, drainage water) may increase the concentration of potential contaminants within sediments around the Prelude FLNG following settlement, precipitation and/or adsorption to particulates. This slight elevation in contaminant levels above background concentrations is anticipated to occur over a period of 10's of years as described further in Section 9.9. Sediment quality in the vicinity of the FLNG and Operational Area is characteristic of the conditions of the offshore region and well represented within the Browse Basin.
	Air quality	Limited environmental impact to air quality. Defined as no substantial change in air quality which may adversely impact on biodiversity, ecological integrity social amenity or human health.	The Operational Area is located in the open ocean and is far-removed from the nearest residential or sensitive populations of the WA coast, with limited interaction with regional airsheds. It should be noted that risks and impacts to the workforce associated with this petroleum activity are addressed in the corresponding Safety Case and are not addressed in this EP. The MNES Significant Impact Guidelines 1.1 under the EPBC Act 1999 (DoE 2013) define significant impact to air quality as 'substantial change in air quality which may adversely impact on biodiversity,

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
			ecological integrity; social amenity or human health'. There is no definition of the term 'substantial' however the above definition highlights that the main concerns are impacts on biodiversity, ecological integrity, social amenity or human health. Due to the lack of background air quality, the NEPM Air Quality and Air Toxics guidelines will be used to judge acceptability of impact on air quality. This is deemed acceptable as the air quality criteria themselves are already conservatively set to afford protection for the health of the general population including its most vulnerable groups such as children and the elderly.
Biological Environment	**Benthic communities**	• Limited environmental impact which directly impacts bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. • Limited environmental impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	• Benthic habitats and communities within the Operational Area are widely represented in the Browse Basin, with millions of hectares of similar broad-scale soft benthic habitats occurring in the region and they not considered of high environmental value. Given there are no named banks, shoals, reefs or islands located within the Operational Area, direct disturbance to benthic habitats contained within the Operational Area are deemed acceptable. • Sensitive benthic receptors (corals, macroalgae, seagrasses and mangroves) associated with shoals, banks, reefs and islands of the Browse Basin and Timor Sea, are considered of high environmental value. Shell considers direct impacts to these receptors as unacceptable. Given the separation distance from the FLNG, these receptors would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. Shell considers any large-scale

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
			hydrocarbon spill to be unacceptable.
	Pelagic communities (Non-Threatened or Migratory)	Limited environmental impact leading to adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	The waters surrounding the FLNG facility are characterised as open offshore waters, typical of the offshore Browse Basin. Resident and transient pelagic species and associated habitat within the Operational Area are not specifically protected or unique and are not considered of high environmental value. Species are regionally well represented and considered typically of the Browse Basin and Timor Sea.
	Key Ecological Features (KEFs)	Limited impact to environmental values of KEFs	KEFs in the Browse Basin are largely geomorphic features that provide important ecosystem services primarily as a result of their unique physical features (e.g. provision of hard substrates, facilitation of upwelling etc.). These are geographically diverse features that cover a large extent. Given there are no planned impacts to KEFs from the Prelude project, any impacts to KEFs will be above the significant impact threshold. Shell considers and impacts to KEFs to be unacceptable.
	Threatened Species and Ecological Communities	N/A – Refer to Section 7.2.4.	N/A – Refer to Section 7.2.4.
	Ramsar Wetlands	Limited environmental impacts to ecological values of Ramsar wetlands	Ramsar wetlands would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. In a regional environmental context, the nearest Ramsar wetland is 169 km away (Ashmore Reef). Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Threatened and Migratory Species	Limited environmental impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES	Shell considers significant impacts to MNES to be unacceptable. Impacts that are below the significant impact threshold defined in Table 8-1 are considered as acceptable.

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
		fauna populations (Refer to Table 8-1).	
	Commonwealth Marine Area	Limited environmental impacts to the Commonwealth Marine Area (Refer to Table 8-1).	Shell considers significant impacts to MNES to be unacceptable. Impacts that are below the significant impact threshold defined in Table 8-1 are considered as acceptable.
	WA Mainland Coastline	Limited environmental impacts to mainland coastline.	The WA mainland coastline would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. Shell considers any large-scale hydrocarbon spill to be unacceptable.
Socio-economic and Cultural Environment	**Heritage**	Limited environmental impacts to defined heritage values	Listed heritage values would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. In a regional environmental context, the nearest heritage place is 155 km away and the nearest named shipwreck is 18 km away (Refer to Section 7.3.1). Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Marine Protected Areas	Limited environmental impacts to ecological values of Marine Protected Areas	Marine Protected Areas would only be impacted by a large-scale hydrocarbon spill, such as a well blowout. In a regional environmental context, the nearest marine protected area is the Commonwealth Kimberley AMP (Approximately 111 km from the FLNG. Shell considers any large-scale hydrocarbon spill to be unacceptable.
	Fishing Industry	• No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	• Impacts or restricted access to targeted fish stocks may measurably reduce the potential revenue for commercial fishers, charter operators or other benefits provided to traditional fishers. Shell considers this to be unacceptable. • In a regional context, commercial, recreational and traditional fishing is typically concentrated mostly in coastal/shallow waters and minimum fishing effort is known to occur within the

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
			vicinity of the Operational Area, given its remoteness offshore. • Shell considers the displacement of other users (e.g. commercial, recreational and traditional fishers) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective.
	Tourism and Recreation	• No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	• Impacts to nature-based tourism resources may deprive the tourism industry of revenue. Shell considers this to be unacceptable. • In a regional context, there are no known tourist attractions or destinations within the Operational Area or nearby surrounds, however charter vessels may transit the broader regional waters. • Shell considers the displacement of other users (e.g. tourism operators) from the Operational Area, which is a relatively small area of the open ocean environment where existing tourism and recreation use is very low, to be acceptable and necessary from a safety and security perspective.
	Defence	• No interference with defence activities as directed by the Department of Defence.	• Shell considers the displacement of other users (e.g. defence vessels and aircraft) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. • In a regional context, there are no designated military/defence exercise areas in the Prelude FLNG facility area and surrounds, however there are regional defence exercise areas with large geographic extents.

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Justification
	Shipping	• No interference with navigation to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	• Shell considers the displacement of other users (e.g. commercial shipping) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. • In a regional context, the major shipping routes traversing the Operational Area are associated with the Prelude FLNG and Ichthys facilities.
	Oil and Gas Industry	• No interference with other titleholders to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out the petroleum activities	• Shell considers the displacement of other users (e.g. petroleum exploration and operations) from relatively small areas of the open ocean environment in the Operational Area to be acceptable and necessary from a safety and security perspective. • In a regional context, the nearest facility/field to the Prelude facility is the Ichthys development which lies approximately 17 km south of the Operational Area.
	Indonesian and Timor-Leste Coastlines	No impacts to Indonesian or Timor-Leste coastlines or nearshore environments are acceptable.	The Indonesian and Timor-Leste coastlines could only be impacted by a large-scale hydrocarbon spill, such as a well blowout. Shell considers any large-scale hydrocarbon spill to be unacceptable.

9.0 Evaluation of Environmental Impacts and Risks

9.1 Introduction

This section documents the process that identifies and evaluates potential environmental impacts and risks and develops means of mitigating the effects of planned activities and the likelihood of unplanned activities of the petroleum activity on the environment, including socio-economic and cultural impacts. It describes the approach undertaken to evaluate the magnitude and severity of impact to environmental and social receptors from activities associated with the petroleum activities. The resulting proposed management controls form the basis of the Implementation Strategy (refer Section 10.0) which will be implemented during the petroleum activity.

9.1.1 Shell Company Approach to Risk Management

At a corporate level, Shell has a standardised Hazards and Effects Management Process (HEMP), as the process by which Shell identifies and assesses hazards and implements measures to manage them. This process is consistent with the principles outlined in the Australian Standard AS/NZS ISO 31000:2009 Risk Management and Handbook 203:2006 Environmental Risk Management (Figure 9-1). HEMP is a fundamental element of the Shell Group HSSE and SP Control Framework and is a process that is applied at every phase of projects and operations.

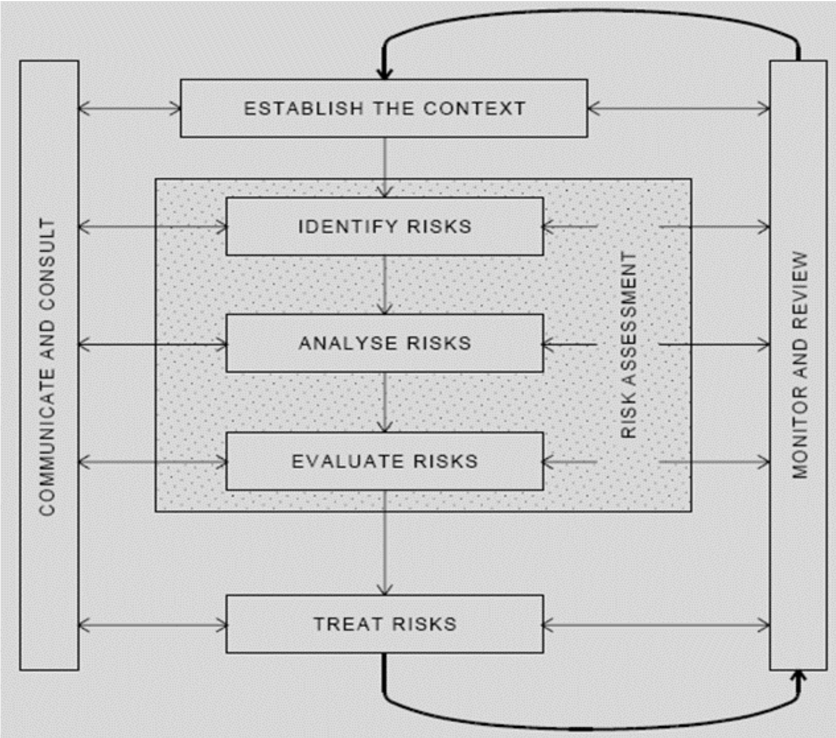

Figure 9-1: Risk Management Framework (AS/NZS 4360:2004 Risk Management

Shell's HSSE and SP Management System is a system that is continually improving due to incorporation of legislative requirements, changing community expectations, improved available technology, ongoing stakeholder engagement, learning from incidents industry wide and within Shell, and regular management review. Assurance that the HSSE and SP Management System is working, continually improving and that each Shell company is correctly applying new Shell standards occurs via local self-assurance and the Shell Global auditing process, which is ongoing and serves to identify gaps and drive gap closure.

Company standards are at least equal to, but in many cases more stringent than local legislation, and aligned with global good industry practice benchmarks such as those published by the IFC and World Bank. Both legislation and company standards are continually being updated and requiring a higher level of performance over time. Concurrently new technologies are becoming available and making improved performance possible and more affordable. This continual improvement is reflected in more challenging ALARP and acceptability benchmarks, leading to better environmental outcomes over time.

The OPGGS (E) Regulations 13(5)(b) requires that the Environment Plan includes 'an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk'. This is further clarified by Reg. 13(6) which states that: 'To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all environmental impacts and risks arising directly or indirectly from (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.' Based on this, Shell has chosen to present ALARP demonstrations for all identified impacts and risks, regardless of their ranking.

The succeeding sections detail the environmental impacts and risks of operations associated with the Prelude FLNG petroleum activities on the local and wider environment, including socio-economic considerations. Activities are described in terms of magnitude/sensitivity and ranking of planned impacts and unplanned risks. A description of management actions proposed to reduce any effect on the environment to As Low As Reasonably Practicable (ALARP) is also presented.

9.2 Impact Assessment Methodology

This section describes the approach adopted for identifying and assessing impacts on the environment as relevant to the petroleum activities. Planned activities give rise to environmental impacts, while unplanned and accidental events pose a risk of environmental impact, if they occur. The risk of environmental impacts resulting from unplanned or accidental events is evaluated by taking the likelihood of the event occurring as well as the consequence into consideration.

The approach aligns with Shell's methodology that enables a balanced assessment of planned impacts and unplanned risks, noting that there are some difficulties in relying solely on the corporate Shell Risk Assessment Matrix (RAM) for assessment of planned environmental impacts. Therefore, an adapted methodology has been developed by Shell (United Kingdom), for use across Shell Group companies, that ties together both potential 'Magnitude' of a predicted impact and the 'Receptor Sensitivity' as shown in a summary impact ranking matrix (see Section 9.2.2). The matrix is used for the assessment of impacts consequences for both planned and unplanned events. However, for the assessment of unplanned events, the additional likelihood of occurrence of an event is taken into account to determine the risk ranking (See Section 9.2.3).

For the purpose of this assessment, key terminology is defined in Table 9-1.

Table 9-1: Definition of Key Terminology for Impact Assessment

Term	Definition
Acceptable	The level of impact and risk to the environment that may be considered broadly acceptable with regard to all relevant considerations.
Activity	Components or elements of work associated with the project. All activities associated with the project have been considered at a broad level (as outlined in Section 6).
ALARP	The point at which the cost (in time, money and effort) of further Risk or Impact reduction is grossly disproportionate to the Risk or Impact reduction achieved
Aspect	Elements of the proponent's activities or products or services that can interact with the environment. These include planned and unplanned (including those associated with emergency conditions) activities.
Control	A measure which mitigates risk through the reduction of the likelihood for a consequence to occur. Controls include existing controls (i.e. Company management controls or industry standards) or additional controls (i.e. additional measures identified during the risk assessment processes).
Event	An occurrence of a particular set of circumstances. An event can be one or more occurrences and can have several causes.
Factor	Relevant physical, biological, socio-economic and cultural features of the environment. These are also referred to as values, sensitivities and/or receptors.
Hazard	A substance, situation, process or activity that has the ability to cause harm to the environment.
Impact	Any change to the environment from a planned activity, whether adverse or beneficial, wholly or partially resulting from a proponent's environmental aspects.
Impact Consequence	The outcome of a planned or unplanned event, which can lead to a range of worst case, credible consequences. A consequence can be certain or uncertain and can have positive or negative effects. Consequences can be expressed qualitatively or quantitatively.
Inherent risk	The potential exposure defined as the plausible worst-case event in the absence of controls
Likelihood	Description of probability or frequency of a consequence occurring with safeguards in place.
Residual risk	The level of risk remaining after risk treatment, i.e. application of controls (inclusive of unidentified risk).
Residual Impact	The level of impact remaining after impact treatment, i.e. application of controls (inclusive of unidentified impact).

9.2.1 Aspects and Impact/Risk Identification

The initial identification of aspects and potentially associated impacts/risks is carried out prior to any detailed assessment of the relative importance of each issue, the sensitivity of the existing environmental and/or socio-economic values, or the magnitude of the potential impact, and does not take into account potential control measures.

The key project aspects arising from the Prelude petroleum activities have been identified as:

- Physical presence
- Lighting
- Underwater noise

- Seabed disturbance
- Vessel movements
- Liquid discharges
- Atmospheric emissions
- Greenhouse gas emissions
- Waste
- IMS (unplanned)
- Loss of containment (including unplanned spills).

9.2.2 Evaluation of Impacts

Impact Consequence Assessment

The ranking of environmental impact consequence is assessed in terms of:

- magnitude based on the size, extent and duration/frequency of the impact; and
- the sensitivity of the receiving receptors.

These are described further below.

Magnitude

Levels of magnitude of environmental impacts are outlined in Table 9-2. The magnitude of an impact or predicted change takes into account the following (shown descriptively in Figure 9-2):

- nature of the impact and its reversibility
- duration and frequency of an impact
- extent of the change
- potential for cumulative impacts.

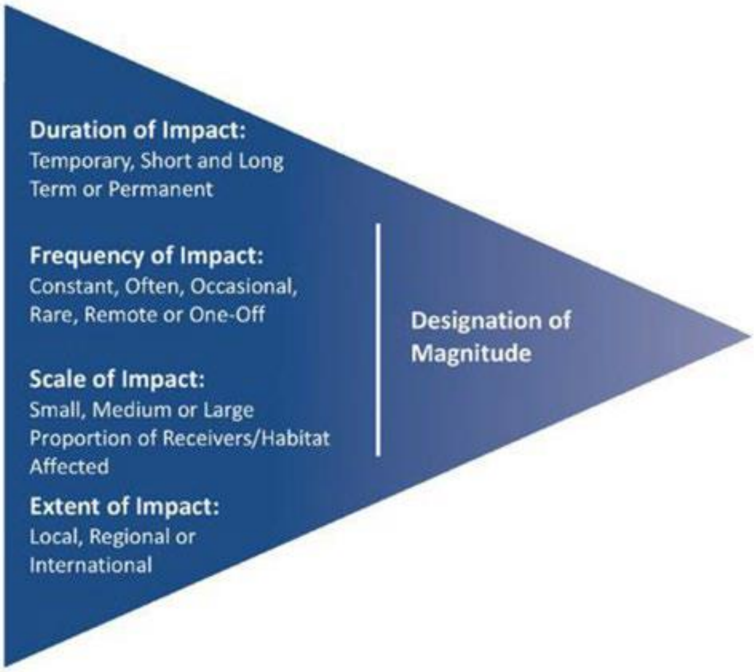

Figure 9-2: Definition of Magnitude in the Context of Impact Identification and Classification

The impact magnitude is defined differently according to the type of impact. For readily quantifiable impacts, such as noise or liquid discharge plume extent, numerical values can be used whereas for other topics (e.g. communities and habitats) a more qualitative definition is applicable. These criteria capture high level definitions, adapted as appropriate to the offshore context of the Prelude project.

Table 9-2: Magnitude Criteria

+1	• Net positive effect arising from a proposed aspect of the petroleum activity
0	• No environmental damage or effects
-1	• Slight environmental damage contained within the Operational Area • Effects unlikely to be discernible or measurable • No contribution to trans-boundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, not effecting usage
-2	• Minor environmental damage, no lasting effects or persistent effects are highly localised • Minor change in habitats or species • Unlikely to contribute to trans-boundary or cumulative effects • Short-term or localised decrease in the availability or quality of a resource, likely to be noticed by users
-3	• Moderate environmental damage that will persist or require cleaning up • Widespread change in habitats or species beyond natural variability • Observed off-site effects or damage, e.g. fish kill or damaged habitats • Decrease in the short-term (1–2 years) availability or quality of a resource affecting usage • Local or regional stakeholders' concerns leading to complaints

	• Minor trans-boundary and cumulative effects
-4	• Severe environmental damage that will require extensive measures to restore beneficial uses of the environment • Widespread degradation to the quality or availability of habitats and/or wildlife requiring significant long-term restoration effort • Major oil spill over a wide area leading to campaigns and major stakeholders' concerns • Trans-boundary effects or major contribution to cumulative effects • Mid-term (2–5 year) decrease in the availability or quality of a resource affecting usage • National stakeholders' concern leading to campaigns affecting Company's reputation
-5	• Persistent severe environmental damage that will lead to loss of use or loss of natural resources over a wide area • Widespread long-term degradation to the quality or availability of habitats that cannot be readily rectified • Major impact on the conservation objectives of internationally/nationally protected sites • Major trans-boundary or cumulative effects • Long-term (> 5 year) decrease in the availability or quality of a resource affecting usage • International public concern

Receptor Sensitivity

For this EP, receptors are grouped into the following primary categories (as described further in Section 7.0 and further broken down into sub-categories):

- Physical environment
- Biological environment
- Socio-economic and cultural environment.

Receptor sensitivity criteria are based on the following key factors:

- Importance of the receptor at local, national or international level – for instance, a receptor will be of high importance at international level if it is categorised as a designated protected area (such as a Ramsar site). Areas that may potentially contain high value habitats are of medium importance if their presence/extent have not yet been confirmed.

Sensitivity/vulnerability of a receptor and its ability to recovery – for instance, certain species could adapt to changes easily or recover from an impact within a short period of time. Thus, as part of the receptor sensitivity criteria (Table 9-3).

- professional judgement considers recovery time of a receptor from identified impacts. This also considers if the receptor is under stress already.
- Sensitivity of the receptor to certain impacts – for instance, flaring emissions will potentially cause air quality impacts and do not affect other receptors such as seabed.

Table 9-3: Receptor Sensitivity Criteria

Sensitivity	Environmental Impact
L	Receptor with low value or importance attached to them, e.g. habitat or species which is abundant and not of conservation significance, or immediate to short-term recovery and easily adaptable to changes.
M	Receptor of Medium importance, e.g. recognised as an area/species of potential conservation significance for example, KEF or listed threatened species, or Recovery likely within 1–2 years following cessation of activities, or localised medium-term degradation with recovery in 2–5 years.
H	Receptor of High importance, e.g. recognised as an area/species of potential conservation significance with development restrictions for example marine parks or conservation reserves, or habitat critical to the survival of a species, or Recovery not expected for an extended period (> 5 years following cessation of activity) or that cannot be readily rectified.

Impact Consequence Ranking

The magnitude of the impact and sensitivity of receptor are then combined to determine the impact consequence ranking in accordance with Table 9-4 below. Key management controls are subsequently identified to reduce the magnitude for such an event occurring in order to determine the final residual impact ranking.

Table 9-4: Impact Consequence Ranking Matrix

		Sensitivity		
		L	M	H
Magnitude	+1			
	0			
	-1			
	-2			
	-3			
	-4			
	-5			

Residual Impact Consequence Ranking	Residual Impact Acceptability Categories
Positive Impact Consequence	Inherently acceptable - Manage for continuous improvement through effective implementation of the HSSE and SP management system
No Impact Consequence	
Slight Impact Consequence	
Minor Impact Consequence	
Moderate Impact Consequence	Acceptable with controls - Apply the hierarchy of control to reduce the risks to ALARP
Major Impact Consequence	Unacceptable
Massive Impact Consequence	

Unplanned Risks (Addition of Likelihood Criteria)

For unplanned/emergency events, the likelihood of such an event occurring also requires assessment in association with the impact consequence to determine the risk ranking. For example, based on magnitude and sensitivity alone a hydrocarbon spill associated with a long-term well blowout would be classed as having a major impact consequence, however, the inherent likelihood of such an event occurring would typically be in the range of unlikely to remote. In addition, the mitigation measures for such impacts focusses on reducing the likelihood of the impact occurring as opposed to reducing the magnitude of the impact itself. Thus, unplanned events also require assessment in terms of residual risk.

As with planned activities, the potential impacts of unplanned events are initially identified, and the impact consequence ranking is determined, which inherently takes into account the magnitude of the event and sensitivity of the relevant receptor(s). The impact consequence ranking is then combined with the likelihood of the event occurring (Table 9-5) in order to determine the overall environmental risk ranking via Table 9-6. Controls are then identified to reduce the risk of such an event occurring in order to determine residual risk.

Table 9-5: Likelihood Criteria

A	• Never heard of in the industry – extremely remote • < 10^{-5} per year • Has never occurred within the industry or similar industry but theoretically possible
B	• Heard of in the industry – remote • 10^{-5} – 10^{-3} per year • Similar event has occurred somewhere in the industry or similar industry but not likely to occur with current practices and procedures
C	• Has happened in the Company or more than once per year in the industry – unlikely • 10^{-3} – 10^{-2} per year • Event could occur within lifetime of similar facilities. Has occurred at similar facilities
D	• Has happened at the location or more than once per year in the Company – possible • 10^{-2} – 10^{-1} per year • Could occur within the lifetime of the development
E	• Has happened more than once per year at the location – likely • 10^{-1} – > 1 per year • Event likely to occur more than once at the facility

Table 9-6: Environmental Risk Matrix (Unplanned Events)

Residual Impact Consequence	Likelihood A	Likelihood B	Likelihood C	Likelihood D	Likelihood E
No Impact Consequence	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Slight Impact Consequence	Light Blue	Light Blue	Dark Blue	Dark Blue	Dark Blue
Minor Impact Consequence	Light Blue	Dark Blue	Dark Blue	Yellow	Yellow
Moderate Impact Consequence	Dark Blue	Dark Blue	Yellow	Yellow	Red
Major Impact Consequence	Dark Blue	Yellow	Yellow	Red	Red
Massive Impact Consequence	Yellow	Yellow	X	X	X

Residual Risk Acceptability Categories	
Light Blue Dark Blue	Inherently Acceptable - Manage for continuous improvement through effective implementation of the HSSE and SP management system
Yellow Red	Acceptable with Controls - Apply the hierarchy of control to reduce the risks to ALARP
Red - X	Unacceptable

For the purpose of the Prelude petroleum activities risk review, the following key risks were assessed in accordance with the risk-based approach summarised in this section:

- Vessel movements, in the context of unplanned interactions with marine fauna
- IMS
- Unplanned release of wastes
- Unplanned (spill) events.

9.2.3 Assessment of Residual Impacts and Risks

The iterative impact and risk assessment process takes into account the mitigation measures that have been adopted as part of the project design and project plan. As such, each impact and risk will be re-assessed taking additional mitigation measures, controls and safeguards into account in order to determine the residual impact (or risk for unplanned events). In the evaluation of residual impacts and risks, all controls are assumed to be implemented effectively and functioning as intended.

The residual impacts and risks detailed in Sections 9.3-9.14 represent a discussion of the various sub-category environmental value/receptor rankings as determined. The residual rankings displayed in the summary tables in the respective sections represents the highest residual impact or risk for each primary receptor category where relevant (i.e. physical environment, biological environment, and socio-economic/cultural environment), and therefore can be considered a conservative assessment for some individual environmental values/sensitivities. These residual impacts and risks are then compared to the acceptability categories outlined in Section 8.0, Table 9-4 and Table 9-6 to determine a final ALARP and acceptability statement.

Cumulative environmental impacts and risks are also considered and discussed where relevant through the impact and risk assessment process taking into account current and foreseeable pressures on the environment including other petroleum activities, other marine industries and users, and other ecosystem pressures.

9.2.4 ALARP Assessment

ALARP for Shell means, the point at which the cost (in time, money and effort) of further risk or impact reduction is grossly disproportionate to the risk or impact reduction achieved.

ALARP can be demonstrated through a number of mechanisms via:

- a quantitative method, such as via technical assessments (e.g. modelling studies) or where the costs of the various options can be compared with the respective impact/risk reduction
- semi-quantitative method where impacts/risks within a certain level require a pre-defined number of barriers of a certain effectiveness in place to prevent this hazard being released, or via
- qualitative analysis, whereby ALARP is established using standards, legislative requirements and judgement based on experience.

Shell applies the following hierarchy of control process to demonstrate ALARP as shown in Figure 9-3.

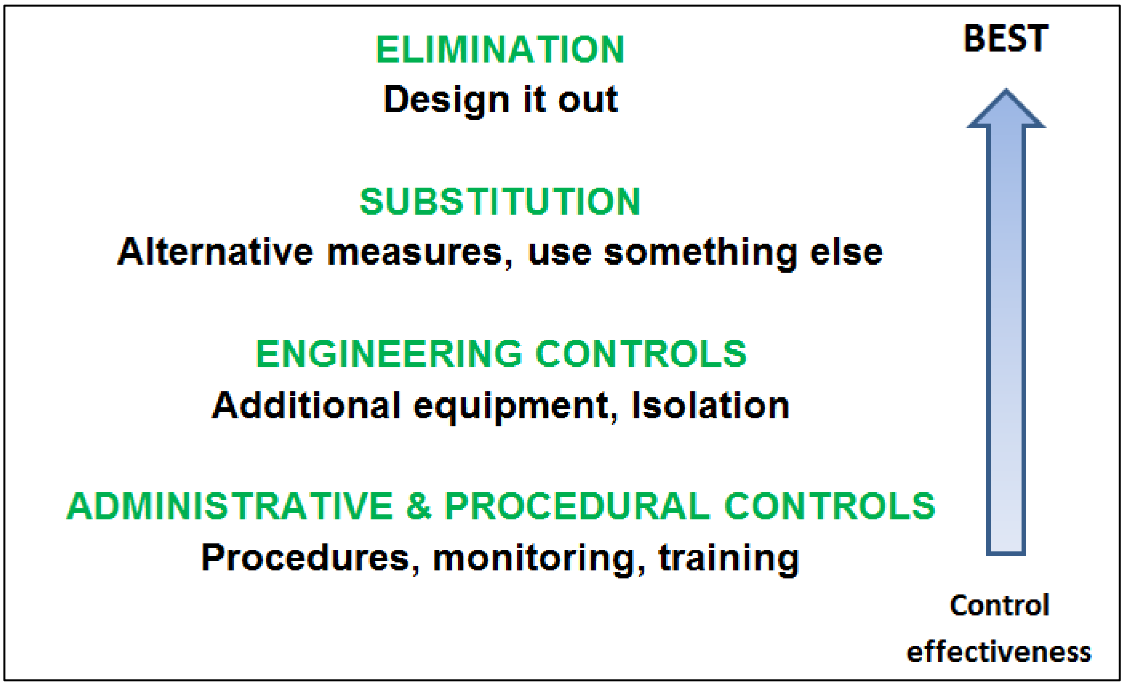

Figure 9-3: Hierarchy of Controls

9.3 Physical Presence

9.3.1 Aspect Context

The physical presence of the Prelude FLNG facility, associated subsea infrastructure and support vessels could potentially affect activities and access to areas associated with fishing, tourism, defence, commercial shipping and the oil and gas industry in the region. Refer to Section 6.0 for a description of the FLNG facility and supporting activities/infrastructure.

A PSZ of 500 m has been established and gazetted around the FLNG mooring chain touchdown locations and well centre (DC-1P), as per the OPGGS Act (NOPSEMA 2015), from which unauthorised marine users are prohibited from entering. The PSZ is a key safety measure to reduce potential interactions with the FLNG facility and associated subsea infrastructure. Temporary exclusion zones will be maintained around any required vessel-based campaigns outside of the PSZ as required.

9.3.2 Description and Evaluation of Impacts

Biological Environment

Pelagic Communities

Fish species, particularly site resident species, will be attracted to the FLNG facility hull and subsea infrastructure. The physical presence of this infrastructure is expected to have a positive effect on fish species diversity and abundance resulting from the creation of an artificial reef in an area which consists primarily of soft, unconsolidated sediments. Given the low sensitivity of the receptors, the provision of this artificial habitat is anticipated to have a positive residual impact with increased species diversity, richness and populations in the immediate area.

Threatened and Migratory Species - Birds

Given the offshore location and distance from the closest bird related BIA (>59km) and Ramsar Wetland/KEF (>134km from Ashmore Reef/Cartier Island), the number of threatened and/or migratory birds encountered within the Operational Area is expected to be low and in the order of individuals. The FLNG facility may provide roosting habitat for seabirds or migratory birds, which may be attracted to the structure to rest. Birds may also be attracted to support vessels to roost, resulting in a temporary behavioural disturbance. The potential behavioural disturbance resulting from the physical presence of the FLNG facility and support vessels within the Operational area is expected to have no credible adverse impact on threatened and/or migratory bird species.

Socio-Economic Environment

The expected impact of the Prelude activities on the fishing industry (commercial, recreational and traditional), is expected in the worst case scenario to be slight due to the significant water depth and low fishing effort in the region and the limited extent of the PSZ in relation to the area available for fishing.

There are no known tourism activities in the area due to the considerable water depths and distance offshore. Therefore, no impacts to tourism are expected.

There are no known defence exercise areas or planned activities within the Operational Area. Therefore, no impacts to defence are expected.

The closest permanent petroleum infrastructure to WA-44-L are the Ichthys facilities about 20 km south of the Operational Area. Exploration activities undertaken by other operators in the region within other permit areas are also possible and likely however, Prelude petroleum activities are not expected to affect these.

Commercial shipping activity in the vicinity of the Operational Area is high and the Prelude petroleum activities are not expected to significantly affect these other activities associated with the Ichthys facility. Overall the worst-case residual impact ranking is assessed as Slight (Magnitude -1, Sensitivity L).

9.3.3 Impact Assessment Summary

Table 9-7: Physical Presence Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	N/A	N/A	N/A
Biological Environment	0	M	No Effect
Socio-Economic Environment	-1	L	Slight

9.3.4 ALARP Assessment and Environmental Performance Standards

Table 9-8: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Physical Presence cannot be eliminated for Prelude activities.	N/A	N/A	N/A
Substitution	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Engineering	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Administrative and Procedural Controls	For specific vessel based campaigns, the Australian Hydrographic Service (AHS) is given advance notification before arrival on location to enable a 'Notice to Mariners' to be issued prior to petroleum activities outside of the PSZ but within the Operational Area.	Yes	Allows notifications to be made to other marine users in the area to minimise disruption to their activities. A 'Notice to Mariners' may be issued by the relevant authority before the activity. However, routine activities undertaken by support vessels to existing offshore infrastructure or facilities do not warrant promulgation of a 'Notice to Mariners'. Similarly, activities occurring within NOPSEMA's gazetted Petroleum Safety Zones do not require promulgation of a 'Notice to Mariners'.	1.2	AHS is given notification in advance to enable a 'Notice to Mariners' to be issued prior to vessel based petroleum activities outside of the PSZ but within the Operational Area.	Records available of advance notification to the AHS which enables issuing of Notice to Mariners' or the relevant Notice to Mariners.

9.3.5 Acceptability of Impacts

Table 9-9: Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	N/A	N/A	N/A	N/A
Socio-economic and Cultural Environment	Fishing Industry	No interference with fishing to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	Shell considers the enforcement of permanent exclusion of activities other than Shell-authorised petroleum activities in the PSZ as legally binding and safer for both the other marine users and Shell. Furthermore, additional temporary exclusions of such users from the Operational Area and potentially its immediately adjacent waters (e.g. due to the physical presence of specific campaigns and the FLNG facility and support, supply and product offloading vessels) is considered to be acceptable and necessary from a safety, security and oil spill prevention (collision) perspective.
	Tourism and Recreation	No negative impacts to nature-based tourism resources resulting in demonstrated loss of income.	Yes	
	Defence	No interference with defence activities as directed by the Department of Defence.	Yes	
	Shipping	No interference with navigation to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out petroleum activities.	Yes	
	Oil and Gas Industry	No interference with other titleholders to a greater extent than is necessary for the exercise of right conferred by the titles granted to carry out the petroleum activities.	Yes	

The assessment of impacts from physical presence determined the residual impact rating of slight (Table 9-4: Impact Consequence Ranking Matrix). As outlined above, the acceptability of the impacts from physical presence associated with the petroleum activities has been considered in the following context.

Principles of ESD

The impacts from physical presence are consistent with the principles of ESD based on the following points:

- The physical presence aspect does not degrade the biological diversity or ecological integrity of the Commonwealth marine area in the Browse Basin.
- Significant impacts to MNES will not occur.
- The health, diversity and productivity of the marine environment will be maintained for future generations.
- The project does not significantly impinge upon the rights of other parties to access environmental resources (e.g. commercial and traditional fishers).
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts and risks.

Relevant Requirements

Management of the impacts from physical presence are consistent with relevant legislative requirements, including:

- Section 616 of the OPGGS Act
- Compliance with international maritime conventions, including:
  - STCW Convention
  - SOLAS Convention
  - COLREGS.
- Compliance with Australian legislation and requirements, including:
  - Navigation Act 2012:
    - Marine Order 21 (Safety of Navigation and Emergency Procedures)
    - Marine Order 30 (Prevention of Collisions)
    - Marine Order 71 (Masters and Deck Officers).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of impacts from the physical presence of the Prelude FLNG facility, associated subsea infrastructure and marine vessels indicates no potential for significant impacts to threatened and migratory species.

Commonwealth Marine Environment

The evaluation of impacts from the physical presence of the Prelude FLNG facility, associated subsea infrastructure and marine vessels indicates significant impacts to the Commonwealth Marine Environment are not credible.

External Context

There have been no objections or claims raised by Relevant Persons to date around the physical presence aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from physical presence determined the residual impact rankings were slight or lower (Table 9-4 Impact Consequence Ranking Matrix). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the physical presence aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the physical presence aspect.

Based on the points discussed above, Shell considers the impacts from physical presence associated with the Prelude petroleum activities to be ALARP and acceptable.

9.3.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No significant impacts to other marine users due to the petroleum activity.	No supported claims reported which demonstrate direct loss of income or other impacts to marine users as a result of undertaking the petroleum activities.

9.4 Lighting

9.4.1 Aspect Context

The Prelude FLNG facility and supporting activities require 24-hour external illumination to meet maritime and operational safety standards. Artificial light emissions will be generated from two primary sources:

- Navigational and operational lighting required for safe function of the FLNG facility and supporting vessels
- Flaring activities from the FLNG facility either from the constantly lit pilot light or during intermittent flaring events as described in Appendix A: Detailed Facility Description.

9.4.2 Description and Evaluation of Impacts

Lighting can create light spill, which has the potential to impact on marine fauna populations for animals that show avoidance or attraction to lights by potentially changing navigational cues that ultimately affect energy expenditure or alter predation and/or feeding rates. Impacts may include the following:

- Disorientation, misorientation, attraction or repulsion
- Disruption to natural behavioural patterns and cycles
- Secondary impacts such as increased predation
- Reduced fitness.

Biological Environment

Reptiles

Of the turtle species identified as protected under the EPBC act, only green turtles (Scott-Browse Stock) are known to nest on Browse Island (~ 40km to the southeast of the Prelude FLNG Project area), with important internesting habitat located within ~20km of Browse Island (Commonwealth of Australia 2017).

Light pollution on nesting beaches can alter critical nocturnal behaviours in adult and hatchling turtles (Commonwelath of Australia 2019). Research suggests that artificial lighting can disrupt or affect the choice of nesting location by female turtles, particularly light visible on the landward side of nesting beaches (Salmon 1992). Turtle hatchlings leaving nesting beaches are particularly sensitive to artificial lighting as they use celestial cues to orientate (Limpus 2008, Salmon et al. 1992; cited in Lorne et al. 1997).

Marine turtle hatchlings may use celestial lights as navigational markers during oceanic migrations and are attracted towards bright lights. Hatchlings can become disorientated and trapped within light spill around platforms and vessels, resulting in increased energy expenditure, increased predation and decreased survival rates (Witherington & Martin 1996; cited in Lorne et al. 1997; Commonwelath of Australia 2019). However, as hatchlings swim offshore from their natal beach, they become less influenced by light cue and rely predominantly by wave motion, currents and the earth's magnetic field (Lohmann and Lohmann 1992).

The table below indicates the extent of visibility of the lighting from the Prelude FLNG facility with respect to turtles (ERM 2009b).

Table 9-10: Line of Sight Limits for Turtles

Light Source	Marine Turtles (limit of light visibility)
Flare (when operating)	51km
Topsides (Process Facilities)	27km
Sky glow from combined luminaries	Effects expected to be minimal given the low levels of particulate matter in the air offshore

Vessels have lower deck height than the FLNG facility therefore, the line of sight assessment undertaken for the FLNG facility suffices for the impact assessment. Even if the FLNG facility is visible, it would only be visible on the seaward horizon and unlikely to alter hatchlings journey from the dunes towards the ocean.

Extensive light attraction studies have been conducted on turtle hatchlings, including at Barrow Island (Pendoley 2005), approximately 1,000 km southwest of the Operational

Area. These studies demonstrated that hatchlings crawl away from tall, dark horizons (sand dunes and vegetation) towards lower and lighter horizons (the sea and stars), and that artificial lighting can alter this response.

Turtles in the nearshore or on the beaches of Browse Island may be able to see the lighting of the Prelude FLNG facility especially during flaring events but this is not expected to have an adverse impact to nesting turtles or hatchlings given the ~40 km separation distance. The flare is potentially visible from the northern beaches of Browse Island low on the seaward horizon with an expected intensity less than that presented by a quarter moon (Imbricata 2018). As the flare is low on the horizon, the Island's landmass blocks light from the flare to the southern beaches so that no beaches on Browse Island are subjected to light from the flare on their landward horizon and the landward horizons remain unaltered to nesting and hatchling turtles. Furthermore, at the date of writing this EP there have been no recorded instances of turtle hatchling sightings or aggregations around the FLNG.

Once in the water, hatchling navigation is influenced predominantly by wave motion, currents and the earth's magnetic field. Hence, there is no expected impact of lighting from Prelude activities on hatchlings once in the water.

Studies also suggest that light generated by flares may not affect hatchlings as much as other light sources. Witherington and Bjorndal (1991) examined the roles of light wavelength and intensity in the sea-finding mechanisms of loggerhead and green turtle hatchlings and found the most disruptive wavelengths to be in the range of 300 to 500 nanometres (nm) (blue – green wavelengths). Spectral analysis of flares at Thevenard Island (Pendoley 2000) suggests that flare light typically does not contain a high proportion of light wavelengths within this range.

There are no important habitat for listed turtle species that are known to be affected by artificial light within 20km of the Operational Area. Important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. The applied 20 km threshold is in alignment and provides a precautionary limit based on observed effects of sky glow on marine turtle hatchlings demonstrated to occur at 15-18 km (Commonwealth of Australia 2019). Therefore, any light generated from within the Operational Area will not result in any environmental damage or effects given the separation distance to the nearest sensitive habitats as follows:

- 23 km to the Green Turtle critical internesting habitat
- 40 km to Browse Island – Turtle nesting and hatchlings.

Given the limited amount of flaring that is expected to occur during normal steady-state operations, the large separation distance of the Prelude FLNG facility from Browse Island and the closest turtle critical habitat and the unaltered landward horizon at Browse Island, there is no expected residual impact consequence from Prelude activities' light spill on turtle hatchlings and adult turtles (Magnitude 0, Sensitivity – M).

There is no literature available on the effects of light on sea snakes. However, anecdotal evidence based on absence of observed sea snakes in waters in the Operational Area suggest that sea snakes are not attracted to artificial light sources.

Birds

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around lit offshore infrastructure (Marquenie et al. 2008) and that lights can attract birds from large catchment areas (Wiese et al. 2001). Either birds may be attracted by the light source itself or indirectly as structures in deep water environments tend to attract marine life at all trophic levels, creating food sources and shelter for birds (Surnam 2002). The light from operating production facilities may also provide enhanced capability for birds to forage at night. Negative potential impacts to birds attracted by artificial lighting are limited but include collisions with infrastructure and alteration of normal behaviours (Commonwealth of Australia 2019).

When considering line of sight with respect to light assessment for birds, the factors that need to be considered include:

- the location and height of the light source (FLNG facility and flare)
- the distance between the light source and the receptor
- the potential elevation of the receptor (birds).

Migratory birds are known to fly at altitudes of between 150 and 600m. To be conservative, the light assessment has used an elevation of 600m as the potential maximum elevation of the migratory birds. Based on a potential flying height of 600m, the light from the FLNG facility will be visible to birds out to a distance of approximately 151km when the flare is operational or 127km when the flare is not being used (ERM 2009b). Table 9-11 indicates the extent of visibility of the lighting from the FLNG with respect to birds.

Table 9-11: Line of Sight Limits for Migratory Birds and Seabirds

Light Source	Birds (Limit of Light Visibility)
Flare (when operating)	151km
Topsides (Process Facilities)	127km
Sky glow from combined luminaries	Effects expected to be minimal given the low levels of particulate matter in the air offshore

If migratory birds are reliant on visual cues in addition to their magnetic compass, such as ambient light, moonlight and starlight to navigate, then artificial light could alter their natural migratory patterns, particularly in the absence of terrestrial landmarks. Light emissions from offshore platforms in the North Sea have been shown to attract migrating birds and birds that migrate during the night are especially affected (Verheijen 1985). During other studies conducted in the North Sea (Marquenie et al. 2008), it was noted that birds travelling within a 5km radius of illuminated offshore platforms may deviate from their intended route and either circle or land on the nearby platform. Beyond this distance, it is assumed that light source strengths were not sufficient to attract birds away from their preferred migration route.

Injuries and mortalities to birds occur through direct collisions with infrastructure and the rate of collision is (as inferred from literature) relates to weather conditions, the cross-sectional area of the obstacle, amount of light and number of birds travelling through an area. Where bird collision incidents have been reported, low visibility weather conditions (cloudy, overcast and foggy nights) have usually been implicated as the major contributing factor, in contrast there are seldom collision incidents on clear nights (Avery 1976; Elkins 1988; Weise et al. 2001). It should be noted that conditions in the Operational Area are not conducive to significant fog formation, however most rainfall is seasonal associated with summer monsoon and cyclones in November to April which does overlap with the peak migratory period for birds as indicated in Section 7.2.8.3 Seasonal Sensitivities of Threatened Species.

According to Bamford et al. (2008), 33 species of migratory birds that use the East Asian-Australian Flyway (EAAF) are regularly present within Australia. The EPBC listed streaked shearwater was not identified as using the EAAF in Bamford's study. Migratory shorebird species are mostly present in Australia during the non-breeding period, from as early as August to as late as April/May each year (DoEE 2017b) As defined previously, the documented zone of impact for migratory birds that resulted in a recorded change in natural behaviour (Marquenie et al. 2008) is two orders of magnitude smaller than the limit of visibility, at a radius of 5 km from an artificial light source.

There are no important habitats for listed bird species that are known to be affected by artificial light within 20 km of the Operational Area. Important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. The applied 20 km threshold provides a precautionary limit based on observed effects of sky glow on fledgling seabirds grounded in response to artificial light 15 km away (Commonwealth of Australia 2019). Therefore, any light generated from within the Operational Area will not result in any environmental damage or effects given the separation distance to the nearest sensitive habitats as follows:

- 59km to the nearest bird breeding BIA.

It is considered possible that small numbers of mature birds may be attracted to the lighting of the FLNG facility. Within the first two years of the FLNG being on location in the Operational Area, there had been recorded observations of one live bird resting on the FLNG and 8 deceased birds of unknown cause, none of which were listed as Threatened. Even if all of the recorded birds could be attributed to a single species with lighting as the key cause, this number would represent a very low proportion of the total number of birds that would have flown through the area within the same timeframe and would be well below what would be considered an ecologically significant proportion. Therefore, it is concluded that under the worst case conditions, there are no expected residual impact consequence (Magnitude – 0, Sensitivy – M).

Pelagic Communities

Fish and zooplankton may be directly or indirectly attracted to lights. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al. 2001), with traps drawing catches from up to 90 m (Milicich et al. 1992). Lindquist et al. (2005) concluded from a study of larval fish populations around an oil and gas platform in the Gulf of Mexico that an enhanced abundance of clupeids (herring and sardines) and engraulids (anchovies), both of which are highly photopositive, was caused by platform light fields.

The concentration of organisms attracted to light results in an increase in food source for predatory species and marine predators are known to aggregate at the edges of artificial light halos. Shaw et al. (2002), in a similar light trap study, noted that juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, may have been preying upon concentrations of zooplankton attracted to the light field of the platforms. This could potentially lead to increased predation rates compared to unlit areas. The intensity of lights may potentially result in a concentration of some marine fauna, although for a period of approximately two years there have been no recordings of significant aggregations of marine fauna from when the FLNG first arrived on location.

The potential for increased predator activity is unlikely to result in a significant impact on the plankton or fish populations. Given the relatively small impact area surrounding the petroleum activities in respect to zooplankton and fish habitat, the potential impacts are expected to be highly localised and unlikely to have discernible consequences at the population level. The distances from Prelude to the closest island (Browse Island) and shoal (Echuca Shoal) are approximately 40 km and 61 km from the Operational Area respectively. Therefore, it is unlikely that artificial lighting will impede or disturb natural lighting cycles that may affect coral spawning.

The range of attraction for fish and invertebrates to lighting from the FLNG facility and support vessels is expected to be localised with no discernible residual impact consequence (Magnitude – 0, Sensitivity - L) and is not expected to attract individuals away from any named shoals/banks, offshore reefs/islands or KEFs. Considering a low receptor sensitivity to such impacts, there are no credible residual impacts at a population level.

9.4.3 Impact Summary

Table 9-12 lists the highest impact consequence rating in the relevant environmental receptor groups.

Table 9-12: Light Emissions Evaluation of Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Physical Environment	N/A	N/A	N/A
Biological Environment	0	M	No Impact
Socio-Economic Environment	N/A	N/A	N/A

9.4.4 ALARP Assessment and Environmental Performance Standards

Table 9-13: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	No lighting	N/A	No additional or alternative control measures have been identified for this impact for the Prelude activities, given the requirement for a well-lit work area.	N/A	N/A	N/A
Elimination	No flaring	No	Occasional flaring is necessary for safe operations. Collection of all flared gas (including pilot and purge) would entail significant cost with the corresponding environmental benefit grossly disproportionate to the additional cost. Flare minimisation is one of the key controls for minimising GHG emissions (see Section 9.11).	N/A	N/A	N/A
Substitution	Use different wavelength lights	No	During the Design Phase of the FLNG facility a lighting assessment was undertaken and the cost comparison indicated as much as 163% extra cost for the changing the lighting to different wavelength lights. Given the low densities of migratory birds and seabirds that may pass through the project area, and that the lighting risk assessment indicates that the impacts to birds and turtles will be nil, it was concluded that installing different spectrum lighting was not demonstrably ALARP for Prelude.	N/A	N/A	N/A
Engineering	Lighting of the FLNG designed to minimise light spill via: Shielding; Use low-spill/ directional lighting; Use of low-reflective paints; Directing luminaires inwards on	No	The use of low-spill/directional and shielded lighting is not warranted due to the distance of the FLNG from the nearest turtle nesting beach (approximately 40km from Browse island) and bird rookery (approximately 162km from Ashmore Reef National	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	the FLNG facility and away from the ocean.		Nature Reserve) and the absence of other light-sensitive fauna around the FLNG location.			
Administrative and Procedural controls	N/A	N/A	No additional or alternative control measures have been identified for this impact for the Prelude activities, given the requirement for a well-lit work area.	N/A	N/A	N/A

9.4.5 Acceptability of Impacts

Table 9-14: Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations.	Yes	Light from the FLNG and support vessels may attract threatened and migratory birds, which may roost on the structures. This is not expected to result in significant impacts at a population level. Light emissions are not anticipated to have a significant impact on marine turtle species.
	Pelagic communities (Non-Threatened or Migratory)	No significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	The range of attraction for fish and invertebrates to lighting from the FLNG facility is expected to be localised and no discernible impacts are expected. The facility is also not expected to attract individuals away from any named shoals/banks, offshore reefs/islands or KEFs. Considering a Low receptor sensitivity to such impacts, there is no credible potential for residual impacts at a population level.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of impacts from light emissions determined no residual worst case impact (Table 9-12). As outlined above, the acceptability of the impacts from light emissions associated with Prelude operations has been considered in the following context.

Principles of ESD

The impacts from light emissions are consistent with the principles of ESD based on the following points:

- The light emissions aspect does not degrade the biological diversity or ecological integrity of the Commonwealth Marine Area and significant impacts to MNES are not anticipated to occur.
- The precautionary principle has been applied, and studies/reviews undertaken (ERM 2009b; Imbricata 2018) where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts.

Relevant Requirements

Management of impacts from light emissions are consistent with relevant legislative requirements, including:

- Draft National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds (Commonwealth of Australia 2019).
- Management of impacts are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-15).
- Implementation of recognised industry standard practice, such as minimisation of flaring.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of lighting impacts indicates significant impacts to threatened and migratory species will not credibly result from the light emissions aspect of Prelude FLNG operations.

Alignment of Prelude operations with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-15.

Commonwealth Marine Environment

The impacts from the light emissions aspect of Prelude operations on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 8-1.

Table 9-15: Summary of Alignment of the Impacts from Light Emissions Aspect of the Prelude field with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory species - Birds	Significant impact criteria for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The evaluation of environmental impacts indicates that impacts from artificial light emissions on threatened or migratory species are likely to be minor and would not constitute a significant impact to populations. As such, residual impacts from artificial light associated with Prelude operations does not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	Wildlife Conservation Plan for Migratory Shorebirds (DoE 2015a)	Managing the light aspect of Prelude operations has been aligned to ‘Objective 4’ of the Plan by ensuring that anthropogenic disturbance was considered in development assessment processes. Migratory birds have been considered as an environmental receptor in the evaluation of lighting impacts.
	Draft National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2019).	Seabirds and migratory birds have been identified in the draft National Light Pollution Guidelines to be affected by artificial light sources. The management of light emissions for Prelude operations has considered the light management actions described in the guidelines and the impact assessment/thresholds have been based on the precautionary limits referenced in the guidelines (Section 9.4.2).

Threatened and Migratory species - Marine Reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The evaluation of environmental impacts indicates that impacts from artificial light emissions on threatened or migratory marine reptiles are slight and would not constitute a significant impact. As such, residual impacts from artificial light associated with Prelude operations do not exceed any of the significant impact criteria for Threatened and Migratory marine reptile species provided in Table 8-1.
	Recovery Plan for Marine Turtles (Commonwealth of Australia 2017)	Light pollution has been identified as a threat in the Recovery Plan for Marine Turtles (Commonwealth of Australia 2017). Nesting females and hatchling turtles are at greatest risk of light impacts; however, the nearest potential nesting habitat is Browse Island (approximately 40 km from the FLNG). Potential light-related impacts to turtles on nesting beaches is considered to be slight. Actions in the Recovery Plan for Marine Turtles (Commonwealth of Australia 2017) relating to the threat of artificial light include: • Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats • Develop and implement best practice light management guidelines for existing and future developments adjacent to marine turtle nesting beaches • Identify the cumulative impacts on turtles from multiple sources of onshore and offshore light pollution Given the Operational Area is beyond any BIAs or habitat critical for the survival of marine turtles (e.g. nesting, inter-nesting or foraging areas) and the light modelling and other studies indicate that impacts to marine turtles will be nil, the actions listed above are not applicable to Prelude operations.
	Draft National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2019).	Marine turltes have been identified in the draft National Light Pollution Guidelines to be affected by artificial light sources. The management of light emissions for Prelude operations has considered the light management actions described in the guidelines and the impact assessment/thresholds have been based on the precautionary limits referenced in the guidelines (Section 9.4.2).
Commonwealth marine area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	The evaluation of environmental impacts indicates that the light emissions aspect of Prelude operations will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the lighting aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts and risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from light emissions determined the residual impact ratings were Nil (Table 9-12) given that any visible light (including sky glow) will not displace or disrupt any MNES listed species from important habitat, nor will it prevent these species from being able to undertake critical behaviours such as foraging, reproduction and dispersal. Shell considers residual impacts of nil to be acceptable if they meet legislative and Shell requirements. To this effect, the acceptability of these impacts have been considered in the context of:

- The established acceptability criteria for the light emissions aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Based on the discussion of these considerations presented above, Shell considers impacts from light emissions associated with Prelude operations to be acceptable.

9.4.6 Environment Performance Outcomes

Environment Performance Outcome	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species as a result of artificial light emissions.	Fauna observations and incident reports demonstrate no mortality of listed Threatened species as a result of artificial light emissions.

9.5 Noise

9.5.1 Aspect Context

Airborne and marine noise emissions from Prelude operations are generated from the following operational sources and activities:

- Subsea infrastructure including wells, pipelines and risers
- Supply and other marine vessel (e.g. ASV during maintenance) operations
- Power Generation and Production Process at the FLNG vessel, including Flaring
- Product Offtake Operations including Tanker Arrival, Loading and Departure
- Helicopter Operations
- Subsea Inspection, Maintenance and Repair (IMR) works.

Subsea Infrastructure

The broadband noise produced by an operational wellhead is very low, 113 dB re 1 µPa, which is only marginally above rough sea condition ambient noise (McCauley, 2002). For this noise level to be exceeded, there would need to be multiple wellheads within a very close proximity of each other (approximately less than 50 m apart) before their signals combine to increase the total noise field (with two adjacent sources only increasing the total noise field by 3 dB). Hence for Prelude field wellheads, the broadband noise level in the vicinity of the wellheads would be expected to be of the order of 113 dB re 1 µPa and this would fall to background levels within less than 200 m from the wellhead (McCauley, 2002). Similar to wellhead noise, which includes flow noise in pipelines, the noise field produced along a pipeline/flowline may be expected to be very close in levels to that described for wellheads, with the radiated noise field falling to ambient levels within approximately a hundred meters. Hence noise impacts from subsea infrastructure including wellheads and flowlines are not considered credible and will not be discussed further.

Subsea IMR activities are typically undertaken from vessels that use a Dynamic Positioning (DP) system. This allows manoeuvrability, station keeping and avoids anchoring when undertaking works in close proximity to subsea infrastructure. As the vessel will maintain its position with the continual use of DP thrusters, the thrusters will dominate as the source of underwater noise. Noise generated from these activities will be intermittent and of short duration and similar to the noise produced by other marine vessels in the field (e.g. supply boats).

Subsea inspections generally involve the IMR vessel travelling along the route of the subsea system with an ROV to identify or undertake maintenance or repair activities that may be required to ensure the assets are being maintained. Inspection techniques with the potential to generate underwater noise include side-scan sonar. Sonars are used in relatively shallow water depths (70 to 240 m) to detect objects on the sea floor including existing infrastructure and potential seabed hazards, however their use will be occasional only, e.g. once every 1-3 years, and only for several weeks at a time. The sonar operates at high frequencies (typically around 100–500 kHz) with the frequency being dependent on the substrate type, resolution of data required, and water depth.

Supply and Other Marine Vessel Operations

During normal operations, support vessels may be required to complete routine round-trip voyages between the Operational Area and Darwin or another Australian Port. The underwater noise that is produced by vessels arises from two continuous sources – propeller cavitation and the propulsion machinery (engines) inside the vessel.

Support vessels typically produce sound levels around 160-180dB re 1µPa at 1m generally dominated by low frequencies during transit and drop with reduced speed. As the ship's speed increases, broad band noise such as propeller cavitation and hull vibration noise become dominant over machinery related tones (NRC 2003). When vessels are holding station, frequencies increase considerably with the use of thrusters to maintain position. A vessel using DP produces noise of low frequency, less than 1kHz, with broadband values up to 177dB re 1µPa at 1m (Simmonds et al. 2004)

Power Generation, Production and Product Offtakes

When the FLNG thrusters are not operating, the facility's underwater noise signature is dominated by the noise produced by the utilities (e.g. power generation) and production facilities. These include the steam turbine generators, boilers, air compressors, and pumps located within the hull and topsides process equipment including compressors and motors. Other production related noise contributors include occasional hydrocarbon flaring and continuous acid gas venting.

The resulting noise amplitudes from Prelude normal operations are predicted to peak at 50Hz, and the overall source level in the frequency range 10Hz to 2kHz is predicted to be 189.1dB re1µPa at 1m. Figure 9-4 shows predicted maximum received noise levels from FLNG facility plant as described.

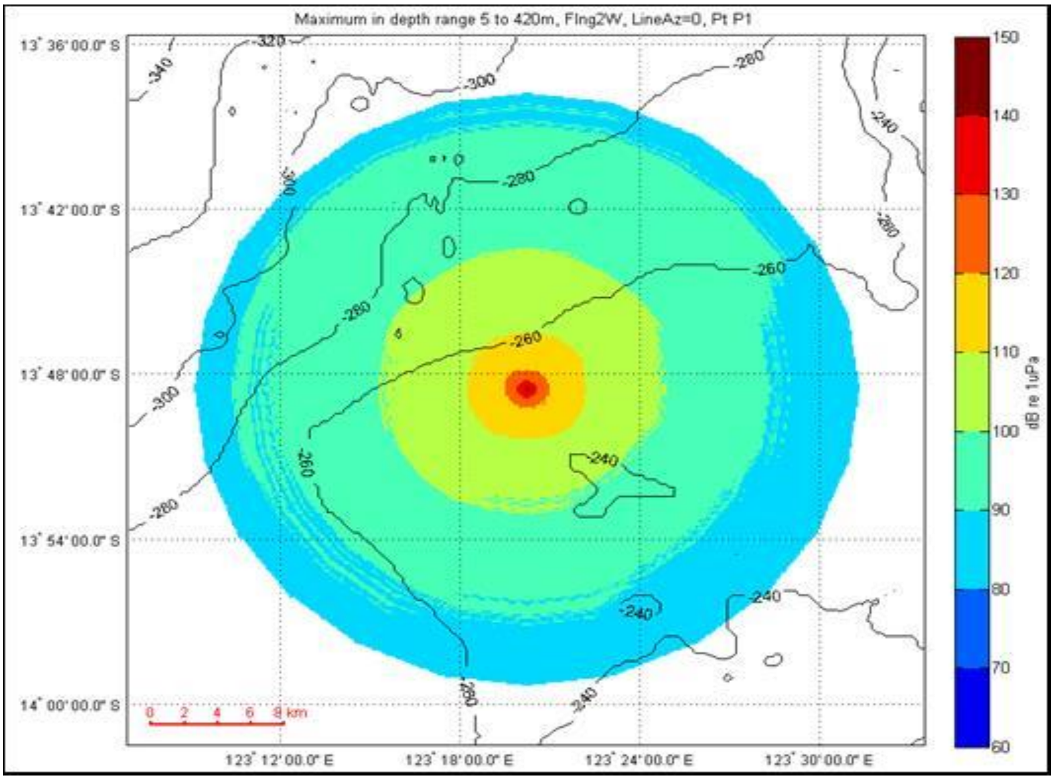

Figure 9-4: Predicted Maximum Received Levels at Any Depth Due to Non-Offtake FLNG Facility Noise as a Function of Range and Azimuth

The highest underwater noise levels will be experienced when the vessel's thrusters are used to maintain position. The requirement to use thrusters is determined by weather conditions and may occur during the berthing and de-berthing of the product offtake vessels and on occasions throughout the off-loading period. Thrusters may also be required during helicopter operations.

The alongside offloading configurations for the LNG and LPG carriers may involve the simultaneous operation of thrusters on the FLNG facility, thrusters on the two in-field support vessels (acting as tugs), and the main engines of the berthing tanker. Thrusters on the FLNG facility and tugs generate high levels of thrust in poor flow conditions, resulting in significant propeller cavitation and consequent high underwater noise levels.

Predicted noise levels peak in the frequency range 200Hz to 400Hz. The corresponding broadband source levels over 10Hz to 2kHz are predicted to be 189.1dB re 1µPa at 1m for the FLNG facility, and 189.7dB re 1 µPa at 1m for the combined effect of two tugs. If all sources are co-located, their combined source level is estimated at 192.4dB re 1µPa at 1m. Figure 9-5 shows the maximum predicted received level of noise at any depth as a function of range and azimuth for the different sources during offtake operations, as well as their combined effect.

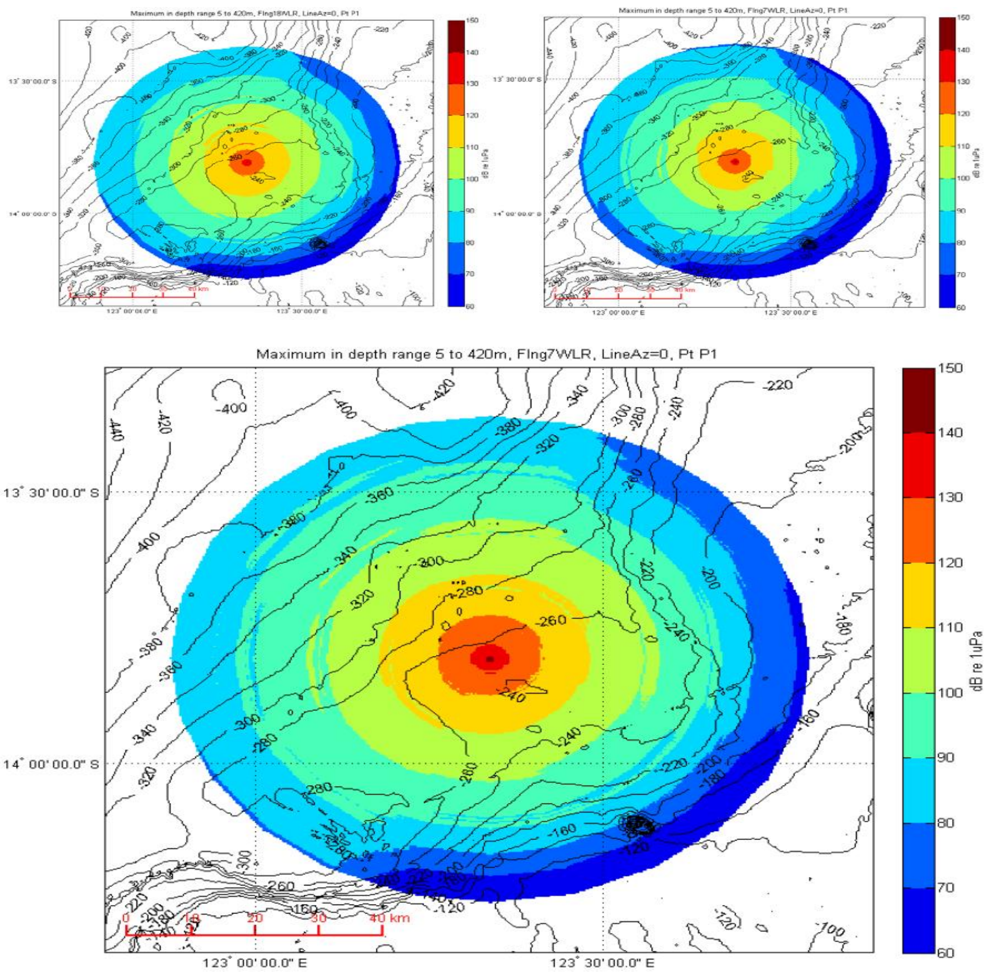

Figure 9-5: Predicted Maximum Received Levels at Any Depth due to Cavitation Noise. Top Left FLNG Facility Only; Top Right: 2 x Tugs only; Bottom: Combined Effect of Tugs and FLNG Facility. Note Change in Scale Compared to Previous Figure

Table 9-16 illustrates the maximum distances from Prelude at which particular noise levels from normal operations and offtake operations are likely to be exceeded.

Table 9-16: Maximum Distance from FLNG at Which the Specified Received Levels are Likely to be Exceeded

Received Noise Level in 10Hz to 2kHz band (dB re 1µPa)	Cavitation noise during offtake operations	Plant noise during operations
160	60m	17m
150	200m	50m
140	850m	190m
130	3.7km	600m
120	9km	1.3km

Received Noise Level in 10Hz to 2kHz band (dB re 1µPa)	Cavitation noise during offtake operations	Plant noise during operations
110	17km	4.5km
100	30km	10km
90	44km	20km

Helicopter Operations

Helicopter flights are required from the operating base at Broome or from Djarindjin (Lombadina) Airport to site for the purposes of crew change out. The main acoustic source associated with helicopters is the impulsive noise from the main rotor. Dominant tones in noise spectra from helicopters are generally below 500Hz (Richardson et al. 1995). The level of underwater sound from helicopters is affected by helicopter altitude, aspect and strength of noise emitted, and the receiver depth, water depth and other variables (Richardson et al. 1995).

The angle at which the line from the aircraft and receiver intersects the water surface is important. In calm conditions, at angles greater than 13° from the vertical, much of the sound is reflected and does not penetrate into the water (Richardson et al, 1995). Therefore, strong underwater sounds are detectable for a period roughly corresponding to the time the helicopter is within a 26° cone above the receiver. Richardson (Richardson et al, 1995) reports figures for a Bell 214 helicopter (stated to be one of the noisiest) being audible in air for 4 minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. The maximum received level was 109 dB re 1µPa2. s. Due to their short duration and near surface impacts only, helicopter noise emissions are not considered to be a credible source of noise impact/ risk and will not be discussed further.

Summary

Table 9-17 provides a summary of sound frequencies and sound levels expected from noise sources produced by FLNG activities and support operations.

Table 9-17: Expected Sound Frequencies and Broadband Source Levels of FLNG and Support Operations

Source	Dominant Frequency Range (Hz)	Expected source levels (dB re 1µPa at 1m)
Support vessels	100 -2,000	164-182
Vessel using dynamic positioning (DP)	50 - 1,000	177
Side Scan Sonar	100,000 – 500,000	no data
34m twin diesel work boat	630	159
Tug (pulling empty barge)	37 - 5,000	145 - 166

Source	Dominant Frequency Range (Hz)	Expected source levels (dB re 1µPa at 1m)
Tug (pulling loaded barge)	1,000 - 5,000	161 - 170
Prelude FLNG (normal operations)	< 2,000 (peak 50)	189.1 (10 - 2,000 Hz)
Prelude FLNG and offtake tankers simultaneously using thrusters	< 2,000 (peak 200-400)	192.4 (10 - 2,000 Hz)
Helicopters	< 500	Received levels at 3m water depth of 101-109dB for a Bell 212 helicopter at an altitude of 610-152m respectively.

Source: Woodside Energy Limited 2011 and Shell 2009

Underwater Noise Impact Levels

Marine species with the greatest sensitivity to underwater noise are marine mammals (whales and dolphins), turtles and fish (including larvae). Other species that could be affected by underwater noise include sea snakes, sharks and rays and invertebrates.

Impacts to marine fauna can be grouped in the following decreasing order of effect:

- mortality or potential mortal injury – physical injury that may result in the death of an animal
- impairment:
    - permanent threshold shift (PTS) – a permanent reduction in the ability of an animal to perceive sound. Recovery is not expected to occur.
    - temporary threshold shift (TTS) – a temporary reduction in the ability of an animal to perceive sound. Recovery to pre-exposure levels is expected to occur.
    - masking – no change in the ability for an animal to perceive sound, but biologically meaningful sounds may be “drowned out” by anthropogenic noise.
- behavioural impacts – typically short-term behavioural responses such as avoidance, surfacing etc. Behaviour will return to normal following cessation of the anthropogenic noise.

Impact thresholds for the fauna groups were derived from scientific literature and published guidelines, including:

- Sound exposure guidelines for fishes and sea turtles: a technical report prepared by American National Standards Institute (ANSI)-Accredited Standards Committee S3/SC1 and registered with ANSI (Popper et al. 2014).
- Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NOAA 2018).

Marine Mammals (Cetaceans)

The vulnerability of marine mammals to underwater noise is linked to their ability to perceive sound. Cetaceans can be grouped based on similarities in their hearing. Underwater noise exposure thresholds can then be weighted for each cetacean group to emphasise noise frequencies that a group may be particularly vulnerable to. This approach is described in Southall et al. (2007) and has been applied to a range of underwater noise guidelines and impact assessments on cetaceans. The impact thresholds for continuous (non-impulsive)[7] underwater noise are summarised in Table 9-18. These are derived primarily from technical guidelines published by NOAA (2018).

Table 9-18: Marine Mammal Sound Exposure Criteria (Continuous Noise)

Type of Animal	Generalised Hearing Range[1] [Hz]	PTS – Permanent Injury (received levels)[2]	TTS – Impairment	Behaviour
Low-frequency cetaceans (baleen whales including humpback, blue, sei, fin, brydes, etc)	7 – 35,000	199 dB $L_{E/p,\ 24h}$	179 dB $L_{E/p}$	120 dB L_p
Mid-frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 – 160,000	198 dB $L_{E/p,\ 24h}$	178 dB $L_{E/p}$	120 dB L_p
High-frequency cetaceans (true porpoises, river dolphins, cephalorhynchid, etc.)	275 – 160,000	173 dB $L_{E/p,\ 24h}$	153 dB $L_{E/p}$	120 dB L_p

Notes:

1. Represents the generalised hearing range for the entire group as a composite (i.e. all species within the group), where individual species hearing ranges are typically not as broad.
2. LE/p, 24h is the weighted cumulative sound exposure level (L E,p) and has a reference value of 1µPa2s. The recommended accumulated period is 24 hrs. The weighted cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle).
3. Lp – Continuous (non-impulsive) noises are quantified as Sound Pressure Level (SPL, or Lp) using units of dB re 1 µPa.

Sea Turtles, Fish and Other Fauna

Table 9-19 provides a summary of sound frequencies understood to be utilised by marine fauna and response thresholds, where known. All data, except where noted, is referenced from the most recent and comprehensive scientific literature survey on marine noise from oil and gas activities and impacts on marine fauna, compiled by the Centre for Marine Science and Technology (CMST), Curtin University, Perth (Kent, C. et al., 2016).

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[7] Underwater noise can generally be considered as two types:

- impulsive noise – typically discrete, short duration noises punctuated by periods of low/no noise, characterised by high peak sound pressure levels with relatively rapid rise and decay times, and
- non-impulsive – noises that do not have rapid rise and decay times, typically of longer duration.

Table 9-19: Sound Frequencies Utilised by Marine Fauna and Known Response Levels

Species	Frequency Range	Response levels
Fish	Hearing range: 100 Hz – 1,000 Hz (with peak hearing from 100 Hz – 400 Hz) < 1,000 Hz (whale sharks)	Recoverable injury: 170 dB Lp for 48 hour exposure (Popper et al. (2014). TSS: 158 dB Lp for 12 hour exposure Popper et al. (2014) Avoidance: > 155-165 dB re 1μPa^2.s Physical damage: 210-211 dB re 1μPa^2.s
Turtles	Vocalisation (in air) 300 Hz – 4000 Hz Best hearing sensitivity: 100 Hz – 700 Hz	Avoidance: > 155 dB re 1μPa^2.s at 1m Erratic swimming: > 164 dB re 1μPa^2.s at 1m

Sharks and rays were grouped with fish (Table 9-19) for this assessment of impacts. No suitable published guidelines were identified for sea snakes. Sea snakes were grouped with fish (Table 9-19) for the purposes of this assessment.

While there are reputable published studies indicating the potential for underwater noise to impact upon invertebrates, no suitable published guidelines were identified for the specific receiving environment. Invertebrates have been considered in the assessment of risks and impacts from underwater noise, although no threshold values have been applied.

Modelling Results vs Threshold Levels

Prelude FLNG activities have the potential for localised and temporary noise impacts on marine fauna, including fish, marine turtles and cetaceans. Based on the thresholds outlined above and the hearing bands for different fauna, underwater noise levels would:

- fall below the relevant cumulative permanent hearing damage criteria for all marine fauna except high frequency cetaceans, at all locations.
- fall below the permanent hearing damage criteria for high frequency cetaceans (24-hour cumulative exposure period) within tens of metres of the facility.
- fall below the relevant temporary hearing threshold shift criteria for fish (12-hour exposure period) beyond 60 metres from the facility.
- fall below the relevant temporary hearing threshold shift criteria for cetaceans beyond 150 metres from the facility during offloading operations.
- fall below the relevant behavioural disturbance criteria for cetaceans at ranges beyond 9 km during offtake operations (caviation noise) and 1.3 km during normal production operations (plant noise).

9.5.2 Description and Evaluation of Impacts

Physical Environment

There are no impacts on the physical environment protected under the EPBC Act such as air or water quality. Noise impacts are limited to the biological environment as discussed below.

Biological Environment

Ecosystems, Communities and Habitats

Benthic Communities

Underwater noise generated by operational platforms does not appear to have any detrimental effect on benthic communities. Inspection of fixed platforms worldwide shows these structures serve as artificial reefs and develop relatively diverse benthic communities (Lindquist et al. 2005). Benthic habitat surveys in the Operational Area indicate the presence of diverse but not abundant or sensitive benthic communities. Given the frequency spectrum and intensity of noise generated during production operations, no impacts to benthic communities as a consequence of underwater noise are expected to occur.

Islands, shoals, banks and near the Operational Area may potentially be exposed to increased underwater noise levels as a result of vessels using DP. These host relatively diverse fauna communities, such as demersal fish and marine turtles (see Threatened Species and Ecological Communities below for further discussion). However, given the distance of these islands shoals and banks from the noise sources in the Operational Area and the consequent reduction in noise intensity, the received noise levels will be significantly lower than the source levels. The nearest island to the Prelude FLNG vessel location is Browse Island, which lies approximately 39 km to the south. The nearest shoal, Echuca Shoal, is 61 km south. At these distances noise emissions from the Prelude operations would have fallen to within background noise levels (see Table 9-16), hence there are no credible potential impacts to island communities (Refer to Threatened Species and Ecological Communities below for further discussion of noise impacts on marine turtles).

Pelagic Communities

Pelagic communities in the Operational Area include planktonic communities and pelagic fish and invertebrates. The effects of noise on free swimming pelagic fish are assessed below with Threatened Species and Ecological Communities and are not addressed further in this section.

Planktonic communities comprise a diverse range of taxa, which will differ in their potential to be impacted by underwater noise. Many species of pelagic and demersal fish have a planktonic larval stage.

Modelling studies by the CSIRO indicate that planktonic communities are highly dynamic and have the potential to recover rapidly following disturbance (Richardson et al. 2017). Experiments have shown mixed results of larval stages to underwater noise. For example, experiments on several species of fish larvae and lobster larvae did not detect significant effects as a result of high intensity impulsive noise (Bolle et al. 2012; Day et al. 2016; Payne et al. 2009).

Impacts to planktonic larvae have not been reliably demonstrated under conditions analogous to those that will be encountered during Prelude operations, being orders of magnitude less than that of experimental designs referenced above. The more intensive noise sources are of limited duration (e.g. vessels using DP), which limits the exposure of planktonic organisms. As such, the residual impact consequence to planktonic communities are considered to be Slight (Magnitude -1, Sensitivity – L).

The Operational Area is not expected to host highly abundant or diverse assemblages of fish, sharks or rays. The noise modelling indicates that no exceedance of the permanent injury threshold for any category of fish would occur in the Operational area and underwater noise levels would fall below the relevant temporary hearing threshold shift criteria for fish (12 hr exposure period) within 60 m from the facility. The approximate received level threshold for behavioural disturbance in fish is variable but indicated to be greater than 90dB re 1μPa above hearing thresholds (Popper et al. 2003, Scholik and Yan 2002a, 2002b, Xodus 2009, Hastings et al. 1996; cited in Woodside Energy Limited 2011). Therefore, the highest impact on masking vocalisation and changes to behaviour will occur within tens and hundreds of metres from the facility for pelagic fish and sharks and rays.

Given the highly mobile nature of fish, sharks and rays and their continual sightings in the Operational Area around the hull, it is concluded that continuous noise sources from the FLNG in its production only and simultaneous production and offloading modes of operation will have at most a slight residual impact consequence (Magnitude -1, Sensitivity – L) on these resident and transient populations.

Key Ecological Features

The nearest KEF to the Operational Area are the Continental Slope Demersal Fish Communities, covering a vast area of approximately 33,182 km^2, located approximately 14 km in its closest point to Prelude. These are a high diversity of demersal fish assemblages on the Australian continental slope featuring more than 500 fish species, 76 of which being endemic, which makes it the most diverse slope bioregion in the whole of Australia.

The noise levels at the closest point of this KEF will be between 120 and 110 dB re: 1uPa in the 10Hz to 2KHz band. At these distances there is no potential for permanent, temporary or behavioural impact to fish with moderate potential for masking fish choruses only. Potential impacts to the demersal fish communities are therefore considered not to credible. Other KEFs are too distant from the Operational Area to be credibly impacted by underwater noise.

Threatened and Migratory Species

Marine Mammals

Most cetacean species use sound to communicate (e.g. humpback whale calls) or perceive their environment (e.g. echolocation of prey). This reliance on underwater noise, and their high conservation value, makes cetaceans of concern when assessing potential impacts from underwater noise. Low frequency cetaceans are expected to be most vulnerable to underwater noise from Prelude Operations (cavitation and plant noise) due to the frequency spectra of these noise sources overlapping the functional hearing range of these species (approximately 7 Hz to 30 kHz). Several low frequency cetaceans (blue, humpback, sei, fin and Bryde's whales) were identified as potentially occurring within the Operational Area (Section 7.2.3). Noise monitoring in the Timor Sea for the Barossa development indicated pygmy blue and Bryde's whales are the most likely to occur (McPherson et al. 2016). Detection of low-frequency cetaceans calls were not constant, but occurred sporadically, often in groups or sets of calls.

Mid frequency cetaceans are also vulnerable to underwater noise, although their hearing range means they are more vulnerable to noise frequencies overlapping their functional hearing range (approximately 150 Hz to 160 kHz). Mid frequency cetaceans include most toothed whales, dolphins and porpoises and a number of species of mid frequency cetaceans were identified as potentially occurring within the Operational Area and adjacent ZPI (Section 7.2.3). Noise monitoring in the Timor Sea indicates mid-frequency cetaceans are present year-round (McPherson et al. 2016).

Given that modelling indicates underwater noise levels fall below the relevant cumulative permanent hearing damage criteria for low and mid frequency cetaceans at all locations within the Operational Area and fall below the relevant TTS criteria for cetaceans beyond 150 metres from the facility during offloading operations it is considered that the potential for significant impacts to cetaceans within the Operational area is not credible. Given also that noise levels from Prelude operations fall below the relevant behavioural disturbance criteria for cetaceans at ranges beyond 9 km during offtake operations (cavitation noise) and 1.3 km during normal production operations (plant noise), the overall impact to marine mammals is considered to be Slight (Magnitude -1, Sensitivity -M).

Other sources of noise, associated with short term operations, such as operational flaring or helicopter operations, will be short in duration and largely reflected off the seawater air barrier to be causing any greater impact on cetaceans than a temporary behavioural response. A similar level of impact is expected from use of side scan sonars during subsea infrastructure IMR activities, which due to being high-frequency sounds are known to be outside the hearing thresholds of cetaceans (see data summary in Table 9-17). Impacts from side scan sonars are therefore expected to cause no greater than slight impacts to marine mammals.

Marine vessel underwater noise emissions are of frequencies detectable by marine mammals however the sound levels at the source itself will be of magnitude that could cause at worst a TSS for an animal happening to be in a very close proximity (within tens of meters of the vessel). The most likely impact consequence at these levels is a behavioural response such as avoidance. For a PTS impact to occur, the mammal should be swimming within metres of the vessel for more than 24 hours, which is a non-credible scenario. It is therefore concluded that noise emissions from marine vessels could potentially cause only a slight residual impact on marine mammals (Magnitude -1, Sensitivity - M).

Marine Reptiles

Marine reptiles such as turtles and sea snakes are not known to be particularly sensitive to underwater noise. Research on marine turtles suggests that functional hearing is concentrated at frequencies between 100 and 600 Hz (which is a subset of the low frequency cetacean range). Several turtle species were identified as likely to occur within the Operational Area (Section 7.2.3), although no critical habitat or BIAs overlap the Operational Area. The closest critical marine turtle habitats include green turtle nesting habitat some 17 km from Prelude FLNG and foraging habitat some 43 km from Prelude. Noise levels at the 17 km distance from Prelude are approximately 110 dB re 1uPa during offloading operations only (24 to 48 hrs per week on average) and 90dB re 1uPa for the rest of the time (background plant operations noise) and impacts to marine turtles at this distance are expected to be slight (refer to Table 9-19). All other marine turtle habitats are more than 100 km away from the Operational Area, hence there are no potential for impacts to those. Impacts from marine vessel noise emissions are also expected to be Slight (Magnitude -1, Sensitivity - M) due to the large separation distance between the Operational Area and the closest marine turtle habitats and the continuous nature and sound levels of marine vessel noise at source. Impacts on sea snakes from all sources discussed above are similarly expected to be slight with reference to response levels for fish in Table 9-19.

Whale Sharks

Whale sharks may traverse the Operational Area and broadly the ZPI with a BIA for foraging whale sharks located 33 km from the Operational Area. However, it is expected that whale shark presence within the Operational Area would not be in significant numbers and would be transitory and of short duration. This is consistent with tagging studies of whale shark movements which show continual movement of whale sharks in deeper, open offshore waters (Meekan & Radford 2010). Whale sharks are also not considered to be particularly vulnerable to noise related impacts (refer to response levels for fish in Table 9-19).

Overall, the worst-case residual impact consequence to biological communities is assessed as Slight (Magnitude -1, Sensitivity - M).

Socio-Economic Environment

No reasonably foreseeable adverse impacts from Prelude noise emissions, including consideration of supply vessel and helicopter operations and impacts on commercial fishing stocks (discussed in Biological Environment), have been identified on the socio-economic environment.

9.5.3 Impact Summary

Table 9-20 lists the highest residual impact consequence ranking of the relevant environmental receptor groups.

Table 9-20: Noise Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	N/A	N/A	N/A
Biological Environment	**-1**	**M**	**Slight**
Socio-Economic Environment	N/A	N/A	N/A

9.5.4 ALARP Assessment and Environmental Performance Standards

Table 9-21: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Substitution	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Engineering	N/A	N/A	No additional or alternative control measures have been identified for this risk for the Prelude activities.	N/A	N/A	N/A
Administrative and Procedural Controls	Marine support vessel interactions with threatened and migratory species to follow the of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017).	Yes	The EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017) are recognised as the industry standard for minimising disturbance due to physical presence and noise to whales and dolphins and will be applied to other species as relevant, .i.e. turtles and whale sharks. Given this is a legal requirement for vessels to comply with, standalone EPS and Measurement Criteria have not been developed.	N/A	N/A	N/A
Administrative and Procedural Controls	Infield environmental noise monitoring	No	Marine noise monitoring alone will not prevent impact to marine fauna, but will provide the noise signature of Prelude operations in time.	N/A	N/A	N/A

9.5.5 Acceptability of Impacts

Table 9-22: Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Benthic Communities	No significant direct impacts to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. No direct impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Yes	Benthic habitat surveys in the Operational Area did not indicate the presence of particularly diverse or sensitive benthic communities. Benthic habitats associated with high value sensitive benthic communities e.g. named reefs, banks and shoals are too distant to be affected by noise (i.e. Browse Island is approximately 39 km from the Operational Area and Echuca Shoal is approximately 61 km from the Operational Area). Given the frequency spectrum and intensity of noise generated during production operations and the large separation distances to the nearest high value sensitive benthic communities, no impacts to benthic communities as a result of underwater noise are expected to occur.
	Pelagic Communities including planktonic communities and pelagic fauna	No significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	No exceedance of the permanent injury threshold for any category of fish is predicted to occur in the Operational area and beyond and ambient underwater noise levels would fall below the relevant temporary hearing threshold shift criteria for fish (12 hr exposure period) beyond 60 metres from the facility. Masking vocalisation and changes to

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
				behaviour could occur only within tens and hundreds of metres from the facility. Impacts to widely distributed planktonic communities in the Operational Area have been assessed as 1-Slight.
	KEFs	No impacts to environmental values of KEFs	Yes	The nearest KEF is the Continental Slope Demersal Fish Communities, located approximately 14 km in their closest point to Prelude. The noise levels at this point indicate no potential for permanent, temporary or behavioural impact to fish with moderate potential for masking fish choruses only. Other KEFs are too distant from the Operational Area to be credibly impacted by underwater noise.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations as a result of noise emissions.	Yes	Noise levels emitted from the FLNG and support vessels during normal production and offtake operations have been assessed as potentially able to cause a slight impact on threatened or migratory marine fauna. Side scan sonar sources are of frequencies outside of hearing range of cetaceans. Turtle nesting and inter-nesting habitats are at least 20 km from the FLNG vessel and known whale migration routes and congregation areas are hundreds of kilometres distant from Prelude. Noise emissions would therefore have no significant impact on

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
				threatened and migratory species.
Socio-economic and Cultural Environment	N/A	N/A		N/A

The assessment of impacts from noise determined the worst-case residual ranking of Slight or lower (Table 9-22). As outlined above, the acceptability of the impacts from noise associated with the Prelude operations have been considered in the context of:

Principles of ESD

Impacts from noise emissions are consistent with the principles of ESD based on the following points:

- The noise emissions aspect does not degrade the biological diversity or ecological integrity of the Commonwealth Marine Area and significant impacts to MNES are not anticipated to occur.
- The precautionary principle has been applied, and since the last revision of this EP the most recent and comprehensive scientific literature compilation (Kent et al, 2016) and the most recent international guidelines on noise impacts (Popper et al. 2014) have been reviewed and referenced to ensure latest research and knowledge are taken into account in the evaluation of environmental impacts.

Relevant Requirements

Management of impacts from noise emissions is consistent with relevant legislative requirements, including:

- Assessment of noise impacts is guided by the latest scientific research in defining impact thresholds (Popper et al. 2014) and includes a purpose conducted noise emissions modelling for the main modes of FLNG operation.
- Management of noise impacts is consistent with policies, strategies, guidelines and conservation advice (refer to Table 9-23).
- Marine support vessel interactions with threatened and migratory species to follow the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017), i.e.
    - Marine support vessels will not deliberately approach closer than 50 m to a dolphin, turtle or whale shark; 100 m for an adult whale; 300m for a whale calf; and 150m for a dolphin calf.
    - If the whale, dolphin, turtle or whaleshark shows signs of being distressed, marine support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of noise impacts indicates significant impacts to threatened and migratory species will not credibly result from noise emissions from production, offloading, materials and personnel transfer and subsea infrastructure operations and maintenance aspects of the Prelude petroleum activities.

Alignment of Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-23.

Commonwealth Marine Environment

Impacts from the noise aspect of the Prelude field on the Commonwealth Marine Environment will not exceed any of the significant impact criteria provided in Table 9-22.

Table 9-23: Summary of Alignment of the Impacts from the Noise Aspect of the Prelude petroleum activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species - Marine Mammals	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	Vessel interactions with threatened and migratory species to follow the of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017). A noise assessment consistent with the recommendations of the Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NOAA 2018) was undertaken.
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015–2025 (Commonwealth of Australia 2015a)	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	
Threatened and Migratory Species - Marine Reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1).	The evaluation of environmental impacts indicates that impacts from noise emissions on threatened or migratory marine reptiles are slight and would not constitute a significant impact. As such, the Prelude field does not exceed any of the significant impact criteria for Threatened and Migratory marine reptile species provided in Table 8-1.
	Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017)	Acute and chronic noise pollution has been identified as a threat in the Recovery Plan for Marine Turtles (DoEE 2017), however there are no specific actions in the Plan in relation to noise pollution, except a recognised need to conduct additional research on impacts of noise on turtles. A noise assessment consistent with the recommendations of the Sound exposure guidelines for fishes and sea turtle (Popper et al. 2014) was undertaken.
Other Species – Sharks and Rays	Conservation advice on whale shark (Rhincodon typus) (DoE 2015e)	A noise assessment consistent with the recommendations of the Sound exposure guidelines for fishes and sea turtle (Popper et al. 2014) was undertaken. This considered the potential impacts of underwater noise on whale sharks.

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	The evaluation of environmental impacts indicates that the noise emissions aspect of Prelude operations will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date on the noise aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts and risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from noise determined the residual impact rankings were Slight (Table 9-21). As outlined above, the acceptability of impacts from noise have been considered in the context of:

- The established acceptability criteria for the noise aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of noise of Slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to noise.

Based on the points discussed above, Shell considers the impacts from noise associated with the Prelude project to be acceptable.

9.5.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No injury or mortality to listed Threatened or Migratory MNES species as a result of noise emissions.	Fauna observations and incident reports demonstrate no injury or mortality of listed Threatened or Migratory species as a result of noise emissions within the Operational Area.

9.6 Disturbance to Seabed

9.6.1 Aspect Context

During installation and certain IMR related activities, localised seabed disturbance may occur. Such disturbance may result from activities including, but not limited to:

- Crux riser and umbilical tie-in
- Replacement of subsea equipment/infrastructure
- Temporary wet storage of equipment and/or infrastructure
- Placement of ROV tool baskets and DP transponders
- IMR activities such as free-span rectification, scour protection, groutbag/mattress installation, pipeline secondary stabilisation and/or water jetting/sand displacement to allow access to infrastructure.

The physical presence of permanent infrastructure already installed or following installation is addressed in Section 9.4 is not considered further in this section.

9.6.2 Description and Evaluation of Impacts

Physical Environment

Installation of subsea facilities has physical impact on the seafloor and the associated benthic communities. The significance of the impact depends on the sensitivity of the seafloor habitat being affected. The disturbance footprint associated with the installation of future subsea infrastructure (including the future Crux riser and umbilical tie-in) will be highly localised.

The disturbance from IMR related activities such as rectification and/or stabilisation is expected to be highly localised to discrete areas. The footprint on the seabed of grout bags on the seabed is typically confined to a small area directly below the flowline. The footprint of a grout bag is a consequence of the size of the bag. Bag size selection typically depends on the size of the span that requires rectification; larger spans typically require larger bags; most have a footprint < 100 m2. The footprint of a mattress depends on the size of the mattress being used; typical mattresses cover approximately 100 m2. Mattress size selection is dependent on the scale of the span or stabilisation required. While the need for grout bags or mattresses (if any) is currently unknown, operational experience indicates they will not be required in large numbers given typically the short flowline length/ span requiring support.

Water Quality

The potential for installation and IMR activities to increase turbidity is based on the possibility of sediment resuspension as a result of water jetting, ROV thruster wash, flushing grout lines or via placement of equipment, infrastructure, rock, mattresses or grout bags for example.

ROV thrusters can resuspend unconsolidated material, including sediments, and restrict visibility and operation of the ROV in the immediately vicinity which is counter-productive for the pilot. For this reason, ROV operators aim to minimise thruster wash by reducing use of thrusters adjacent to unconsolidated material, and operating at a height above the sea floor that reduces resuspension.

Any impacts to water quality (turbidity) from seabed disturbance are expected to be restricted to highly localised and short-term sediment plumes. Sediment plumes may result in a slight and temporary decrease in water quality due to increase in suspended sediments. These temporary impacts to water quality are expected to have no credible environmental damage or effects.

Sediment Quality

Impacts to sediment quality from seabed disturbance are considered to have no environmental damage or effects. Significant changes to physical properties, such as particle size distribution and geological origin, are not expected to occur due to the small-scale, localised and infrequent nature of the associated activities.

Biological Environment

The seabed within the Operational Area has low density of epibenthic communities due to the low variance of sea floor topography and absence of hard substrates limiting habitat for epibenthic organisms (Baker et al. 2008; Heyward & Smith 1997). This has been determined for the Prelude location from benthic surveys, side scan sonar, 3D seismic survey and geotechnical data collected across the permit area (Shell 2009).

The soft seabed comprises of very soft siliceous carbonate silts, which has been shown to support a high diversity but low abundance community of infaunal assemblages. The likely impacts to the benthic communities from seabed disturbance include smothering and temporary disturbance but soft sedimentary communities have been shown to respond rapidly to disturbance and impacts are thus expected to be slight and short-lived (Shell 2009).

The habitats associated with these communities are broadly distributed in the wider region and are not considered to be unique or highly sensitive. The installation of additional infrastructure associated with the petroleum activities (including stabilisation or span rectification using grout bags/mattresses) may result in the disruption of a relatively small area of soft sediment habitats, which will then become hard substrate habitats due to the presence of subsea infrastructure.

Given the widespread extent of similar habitat, the low sensitivity of the benthic habitat within the Operational Area, and the high likelihood that temporarily affected areas will recover in a short timeframe, the environmental effects are considered to be of minimal ecological significance. Thus, the overall residual impact consequence level is ranked as Slight (Magnitude -1, Sensitivity – L).

9.6.3 Impact and Risk Summary and Key Management Controls

Table 9-24: Benthic Disturbance Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment	0	L	No Impact
Biological Environment	-1	L	Slight
Socio-Economic Environment	N/A	N/A	N/A

9.6.4 ALARP Assessment and Environmental Performance Standards

Table 9-25: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Eliminate IMR activities	No	The subsea IMR activities (that result in seabed disturbance) are essential for maintaining the integrity of the subsea hydrocarbon system and cannot be avoided. The alternative of doing nothing would potentially compromise the integrity of the system, with increased technical risks and production failures, resulting in significant financial costs and potentially leading to increased risks of loss of containment, resulting in environmental costs.	N/A	N/A	N/A
Substitution	N/A	N/A		N/A	N/A	N/A
Engineering	During installation activities, infrastructure is laid on the seabed according to plan.	Yes	The costs are not disproportionate to the negligible environmental benefit potentially gained through avoiding the small and infrequent seabed disturbances. No improved control measures were considered.	4.1	During installation activities, infrastructure is laid on the seabed within the Operational Area	As-laid surveys are performed following installation activities to confirm the facilities have been laid within the Operational Area
Administrative and Procedural Controls	Anchoring in the Operational Area for support vessels is prohibited except in emergency situations or under issuance of a specific permit by Shell.	Yes	No alternative control measures have been identified.	4.2	No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell	Records verify no breaches of anchoring procedures in the Operational Area.

9.6.5 Acceptability of Impact

Table 9-26: Acceptability of Impact

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Benthic Communities – Bare Sediment	No significant direct impacts to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities	Yes	No significant impacts are expected, given the Operational Area represents a small portion of a large regional bare sediment benthic environment. Habitats associated with these communities are broadly distributed in the wider region and are not considered to be unique or highly sensitive. Any seabed disturbance within the Operational Area will be small in scale, infrequent and represent a small fraction of the overall Operational Area and therefore any impacts are not expected to affect ecosystem function or connectivity of communities.
	Commonwealth Marine Environment	No significant impacts to the Commonwealth Marine Environment	Yes	
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of impacts from seabed disturbance determined the residual ranking of Slight or lower. As outlined above, the acceptability of the impacts associated with the petroleum activity have been considered in the following context.

Principles of ESD

The impacts from seabed disturbance are consistent with the principles of ESD based on the following points:

- Seabed disturbance on such a small scale will not degrade the biological diversity or ecological integrity of the Commonwealth Marine Environment and therefore significant impacts to MNES will not occur.
- The health, diversity and productivity of the marine environment will be maintained for future generations.

- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified (Refer to Section 7.2.1). This knowledge has been applied during the evaluation of environmental impacts.

Relevant Requirements

Management of the impacts from seabed disturbance are consistent with relevant legislative requirements, including:

- Management of impacts are consistent with guidelines for the protection of MNES (Table 8-1).

Matters of National Environmental Significance

Commonwealth Marine Environment

The impacts from the seabed disturbance aspect of the Prelude field on the Commonwealth Marine Environment will not exceed any of the significant impact criteria provided in Table 9-27.

Table 9-27: Summary of Alignment of the Impacts from the Seabed Disturbance Aspect of the Prelude Petroleum Activities with Relevant Requirements for MNES

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth Marine Environment (Table 8-1)	The impact assessment indicates that the seabed disturbance aspect will not exceed the Commonwealth Marine Environment significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the seabed disturbance aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from seabed disturbance determined the residual impact rankings were Slight or lower Table 9-24). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the seabed disturbance aspect
- ESD
- Relevant requirements

- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of Slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the seabed disturbance aspect.

Based on the points discussed above, Shell considers the impacts from seabed disturbance associated with the Prelude petroleum activities to be ALARP and acceptable.

9.6.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No direct disturbance to benthic habitats outside of the Operational Area as a result of the petroleum activities.	Records demonstrate there has been no significant direct disturbance to bare sediment benthic habitats outside of the Operational Area as a result of the petroleum activities.

9.7 Vessel Movements

9.7.1 Aspect Context

Marine vessels moving in the Operational Area may present a hazard to threatened and migratory fauna, such as whales, turtles and whale sharks (though the abundance of such fauna in and around the Operational Area has been observed to be low). Vessel movements can result in collisions between the vessel and marine fauna, potentially resulting in injury or death. Factors affecting the likelihood and severity of impacts from collisions include vessel type, vessel speed, water depth and the behaviours of animals present (Commonwealth of Australia 2017).

9.7.2 Description and Evaluation of Risks

The risks of vessel collisions with marine fauna, particularly threatened and migratory species (i.e. MNES), described below are consistent with the acceptable levels of impacts defined in Section 8.0. Shell's environmental management of the vessel movements aspect of the petroleum activities is aligned with conservation advice, recovery plans and threat abatement plans published by the DoEE; refer to discussion of MNES in the discussion of acceptability below.

Potential risks associated with vessel movements within the operational area are discussed below. As outlined in Section 9.2.3, the assessment considers only the residual risks following the application of controls.

Biological Environment

Threatened and Migratory Species

The Operational Area is not adjacent to or in close proximity to any known important habitats for threatened or migratory species or the humpback whale migration routes.

There are no BIAs or critical habitats within the Operational Area with the closest such areas located 23km away for turtles, 33km away for whale sharks and 78km for marine mammals. Therefore, the abundance of threatened or migratory species in the Operational Area is expected to be low and their presence transient.

Turtles: The Operational Area does not represent important habitat for marine turtles given the absence of potential nesting. Much of the project area is in water depths exceeding 90 m, which is deeper than typical foraging dives by marine turtles (e.g. Hays et al. 2001; Polovina et al. 2003). As such, the presence of marine turtles within the Operational Area is likely to be restricted to individual turtles transiting the area. As with cetaceans, the risk of collisions between turtles and vessels increases with vessel speed (Hazel et al. 2007). The typical response from turtles on the surface to the presence of vessels is to dive (a potential "startle" response), which decreases the risk of collisions (Hazel et al. 2007). Given the low speeds of vessels in the operational area, along with the expected low numbers of turtles in the area, the likelihood of collisions between vessels and turtles is assessed as remote.

Whale sharks: These are at risk from vessel strikes when feeding at the surface. Whale sharks have been observed traversing the Operational Area however, it is expected that whale shark presence would not comprise of significant numbers given there is no main aggregation area within the vicinity, and their presence would be transitory. This is consistent with tagging studies of whale shark movements which show continual movement of whale sharks in deeper, open offshore waters (Meekan & Radford 2010). There are no constraints preventing whale sharks from moving away from vessels (e.g. shallow water or shorelines).

Whales and Dolphins: Whales are particularly vulnerable to collisions with vessels due to their large size and the relatively high proportion of time spent at or near the sea surface. The likelihood and consequence of vessel collisions with whales are influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber 2004; Laist et al. 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk is less than 10% at a speed of 4 knots. Although dolphins are at much lower risk from collision due their small size, manoeuvrability and echolocation abilities compared to whales, they are still included in this assessment given they surface to breathe and are known to feed near the surface at times.

Marine vessels within the Operational Area, carrying out petroleum activities, are likely to be travelling at speed less than 8 knots; much of the time vessels are holding station or moving very slowly under Dynamic Positioning (DP) due to operational safety requirements. Therefore, the likelihood of a vessel collision with threatened or migratory species is remote.

Marine mammals, turtles and sharks are expected to alter course away from the FLNG as well as stationary or slow-moving product offtake, IMR, supply and support vessels in the Operational Area. The cruising speed of supply and support vessels is relatively low and a watch is maintained at all times and any interactions will be managed in line with the requirements of the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017).

This activity is identical to vessel movements for other offshore activities along the Western Australian coastline where the incidence of vessel strike is remote. Any collisions are only likely to affect fauna at an individual scale rather than at a population or species scale. Therefore, an injury or death of an individual from a threatened or migratory species from a collision is considered to be of minor impact consequence (Magnitude -2, Sensitivity – M) and remote likelihood with a residual risk assessed as Dark Blue.

9.7.3 Risk Assessment Summary

Table 9-28: Vessel Collision with Marine Life Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Biological Environment	Minor	B - Remote	**Dark Blue**

9.7.4 ALARP Assessment and Environmental Performance Standards

Table 9-29: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Elimination	N/A	No appropriate control measures have been identified to eliminate this risk from Prelude activities.	N/A	N/A	N/A
Substitution	Substitution	No	The number of vessels used is already considered minimal. Any fewer vessels will not meet operational needs.	N/A	N/A	N/A
Engineering	Engineering	No	No appropriate control measures have been identified to reduce noise through engineering means.	N/A	N/A	N/A
Administrative and Procedural Controls	Administrative and Procedural Controls	Yes	The EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017) are recognised as the industry standard for minimising disturbance due to physical presence and noise to whales and dolphins and will be applied to other species as relevant, .i.e. turtles and whale sharks. Given this is a legal requirement for vessels to comply with, standalone EPS and Measurement Criteria have not been developed.	N/A	N/A	N/A

9.7.5 Acceptability of Risks

Table 9-30: Acceptability of Risks

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations (Refer to Table 8-1)	Yes	Vessel movement risks are of an acceptable level, given the Operational Area is not located in any BIAs or habitat critical to the survival of a species. Given the low speeds of vessels, along with the expected low abundance of threatened and migratory species within the Operational Area, significant impacts to Threatened and Migratory Species are not anticipated.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of risks from vessel movements determined the residual ranking of Dark Blue or lower (Table 9-6), deemed as Inherently Acceptable. As outlined above, the acceptability of risks from vessel movements associated with the petroleum activities has been considered in the following context.

Principles of ESD

Risks from vessel movement are consistent with the principles of ESD based on the following points:

- The vessel movements aspect does not degrade the biological diversity or ecological integrity of the Commonwealth marine area in the Browse Basin. Significant impacts to MNES will not occur.
- The health, diversity and productivity of the marine environment will be maintained for future generations.
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental risks.

Relevant Requirements

Management of risks from vessel movements are consistent with relevant legislative requirements, including:

- Marine support vessel interactions with threatened and migratory species to follow the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017 (DoEE 2017), i.e.
    - Marine support vessels will not deliberately approach closer than 50 m to a dolphin, turtle or whale shark; 100 m for an adult whale; 300m for a whale calf; and 150m for a dolphin calf.
  - If the whale, dolphin, turtle or whaleshark shows signs of being distressed, marine support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.
- Management of risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (refer to Table 9-31 below).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of risks indicates significant impacts to threatened and migratory species will not credibly result from the vessel movements aspects of the petroleum activities.

An unplanned collision between project vessels and threatened or migratory fauna is unlikely to occur and may result in injury to or death of individual animals. This unplanned event is not considered to have the potential for significant impacts to threatened or migratory species at the population level.

Alignment with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-31.

Commonwealth Marine Environment

The impacts and risks from the vessel movements aspect of Prelude operations on the Commonwealth marine environment will not credibly exceed any of the significant impact criteria provided in Table 8-1.

Table 9-31: Summary of Alignment of the Risks from the Vessel Movements Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species – Marine Mammals	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory marine mammals is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	National Strategy for Reducing Vessel Strikes on Cetaceans and other Marine Megafauna (Commonwealth of Australia 2017a)	Vessel movements will be aligned to 'Objective 3: Mitigation' of the Strategy by: • Maintaining separation of vessels and whales; • Maintaining slow vessel speeds; and • Avoidance manoeuvres. This will be met by marine support vessels adhering to Part 8 (Interacting with cetaceans and whale watching) of the EPBC Regulations.

		Note the other objectives of the Strategy relate to actions for Government agencies.
	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	The risk of vessel strikes will be managed by marine support vessels adhering to the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015)	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	
Threatened and Migratory species - marine reptiles	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 7-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory marine reptiles is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia 2017b)	Marine support vessel collisions with turtles are inherently unlikely due to the offshore location (and resultant low densities of turtles), slow speeds of vessels and diving startle response of turtles. Furthermore, the risk of a vessel collision with a turtle will be further reduced via the implementation of the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
	Conservation advice on leatherback turtle (Dermochelys coriacea) (DEWHA 2009a)	
Threatened and Migratory species - sharks and rays	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 7-1)	The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory sharks and rays is remote, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species provided in Table 8-1.
	Conservation advice on whale shark (Rhincodon typus) (DoE 2015e)	The Operational Area is not recognised as a BIA or habitat critical to the survival of whale sharks. The conservation advice recommends minimising offshore developments close to marine features that may aggregate whale sharks and cites Ningaloo Reef and Christmas Island as examples. Studies of whale sharks tagged while aggregating at Ningaloo Reef have shown individuals transiting through the Timor Sea (Meekan & Radford 2010) but showed no evidence of aggregation around particular marine features in the open offshore waters within or in the vicinity of the Operational Area.
Wetlands of International Importance	N/A	N/A

Commonwealth Marine Environment	Significant Impact Guidelines for the Commonwealth marine environment (Table 7-1)	The impact assessment indicates that vessel movements will not exceed the Commonwealth Marine Environment significant impact criteria provided in Table 8-1 as the aspect does not pose a credible risk.

External Context

There have been no objections or claims raised by Relevant Persons to date around the vessel movement aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of the risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

As outlined above, the acceptability of the associated risks have been considered in the context of:

- The established acceptability criteria for the vessel movements aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual risks have been assessed as minor. Shell considers residual risks of minor or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the vessel movements.

Based on the points discussed above, Shell considers the risks from vessel movements associated with the Prelude petroleum activities to be ALARP and acceptable.

9.7.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species associated with vessel collisions within the Operational Area.	Fauna observations and incident reports demonstrate no injury or mortality of listed Threatened or Migratory MNES marine species as a result of vessel movements within the Operational Area.

9.8 Introduction of Invasive Marine Species from Vessels

9.8.1 Aspect Context

Invasive Marine Species (IMS) are non-indigenous marine fauna or flora that have been introduced into an area beyond their natural geographical range, and may have the ability to survive, reproduce and establish a population such that they threaten native species through increased competition for resources and/or increased predation.

The vessels and equipment sourced from outside Australian waters have the potential to introduce or transport IMS to the Operational Area, or potentially to wider area through oceanic currents and transport via activities such as support vessel movements. There are two primary mechanisms which may cause the inadvertent introduction and spread of IMS; hull fouling (biofouling) and ballast water discharges.

Establishment of IMS in the Operational Area requires a sequence of events to occur:

- the potential IMS must be present on (e.g. biofouling) or in (e.g. ballast water) the vector; and
- the potential IMS must be released into the environment (e.g. ballast water discharge, release of propagules from biofouling); and
- the potential IMS must survive, reproduce (either sexual or vegetative reproduction) and subsequently persist in the environment.

The introduction of IMS is recognised globally as a threat to marine biodiversity, and the International Maritime Organisation (IMO) has developed guidelines for the management of biofouling and ballast water. Commonwealth, State and Territory authorities also regulate the risk of IMS from biofouling and ballast water. Vessels operating in Australia are required to meet these requirements, and vessels meeting these requirements pose an inherently lower risk of harbouring IMS or releasing IMS into the environment.

If potential IMS become established in the Operational Area (i.e. on the Prelude FLNG, from tankers or other vessels), support vessels that operate in the field may subsequently provide vectors for translocation of potential IMS. The likelihood of this sequence of events is considered extremely remote given the controls that are routinely applied to vessels (e.g. anti-fouling coating, inspections, hull cleaning etc.), the remote offshore location and nature of typical vessel activities (e.g. short periods alongside the Prelude FLNG during operations).

The Prelude FLNG facility will take up and discharge ballast water regularly as it produces cargoes and exports the products to off take tankers but this ballast water does not pose a credible threat as the FLNG facility is permanently moored and does not travel to or from other ports. Support vessels will generally come from Australian ports and typically stay alongside the Prelude FLNG for short durations (generally in the order of hours) to offload and load materials.

Most native fouling species likely to be encountered within or transiting through the Operational Area will be widely distributed as similar habitats are broadly represented in the Timor Sea and Browse Basin. An IMS may compete with these native species if it were to become established in the Operational Area or wider region. This may decrease the species diversity of benthic communities.

IMS are typically extremely difficult to eradicate once established and reproducing in an area. In the highly unlikely event an IMS becomes established and reproductively viable, it would be almost impossible to eradicate.

Ballast water exchange needs for the support vessels are expected to be limited. All vessels operating in the Operational Area are obliged to conduct ballast tank operations in line with IMO guidelines and, where applicable, comply with the Biosecurity Act 2015.

All known and potential introduced marine pests listed by Australian agencies are nuisance foulers, predators, invasive seaweeds or noxious dinoflagellates that inhabit harbours, embayment's, estuaries, shorelines and/ or shallow coastal waters less than 200m deep (Hayes et al. 2004, Barry et al. 2006). The water depth in the Operational Area is in excess of 200m.

The offshore environment of the Operational Area is relatively deep, oligotrophic (nutrient-poor) and hard substrate habitats do not naturally occur. Many potential IMS are sessile invertebrates that require hard substrate for attachment. In the unlikely event potential IMS are released into the Operational Area, the IMS are highly unlikely to encounter suitable substrate for settlement and establishment. Most potential IMS are adapted to coastal waters, such as ports and harbours. If a potential IMS were to become established in the field, it is unlikely to survive in the relatively deep water offshore environment. The deep water, low nutrient and open ocean environment in Operational Area provides minimal larval retention times or suitable habitat for coastally adapted IMS.

9.8.2 Current Knowledge about IMS on Prelude FLNG and Associated Vessels

Various studies were conducted both prior to and after the Prelude FLNG arrived in the operational area in July 2017 which provides more certainty on the persistence of potential IMS. A detailed summary of the outcomes and timing of various monitoring measures is outlined in Figure 9-6 below.

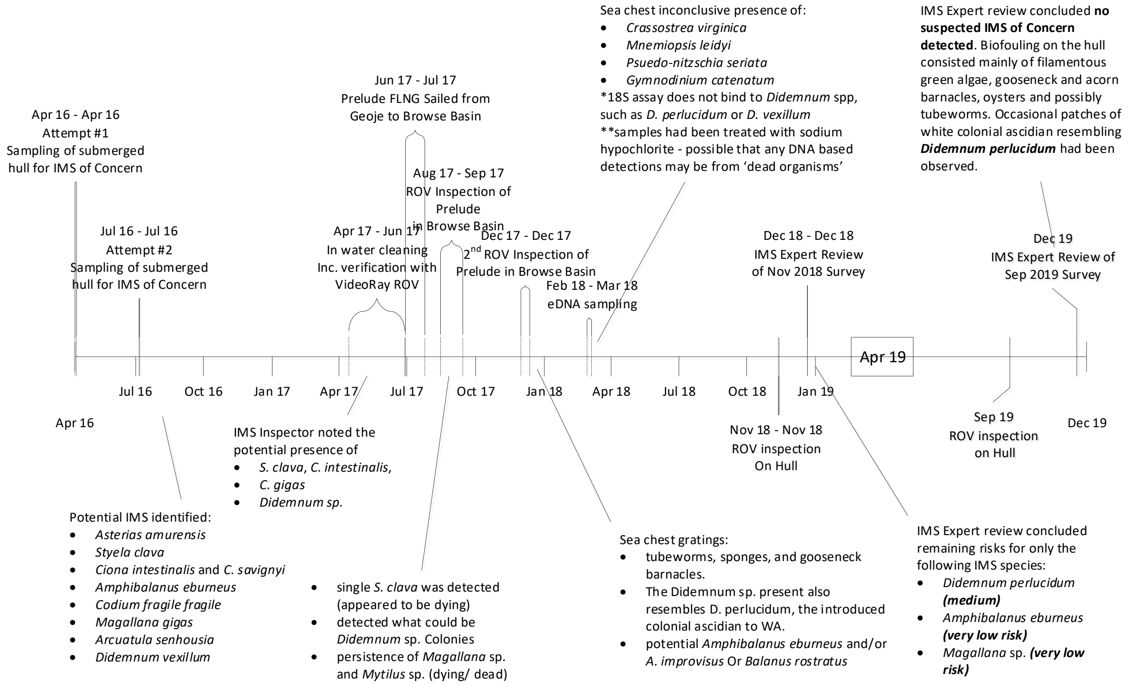

Figure 9-6: Timeline of Prelude FLNG invasive marine species monitoring program since April 2016 until December 2019.

Pre-arrival of Prelude FLNG in the Operational Area, 'ALARP Cleaning' (April - June 2017) was conducted in the Geoje shipyard to reduce IMS numbers and potential inoculum pressure (and was considered the best practicable risk management outcome available). Specific to biofouling management, Shell contracted biofouling specialists to provide advice on the clean-up required as well as inspection services. Biofouling experts have produced the following reports for Prelude pre-mobilisation:

- **International Anti-Fouling System Certificate** from Lloyds Register.
- **IMS Risk Assessment (BFS1445)** – Assessed the risk of Prelude FLNG introducing IMS of concern to Australian waters. The risk assessment is based on "Infection Modes and Effects Analysis" (IMEA) for two IMS management scenarios: 1) Do nothing, and 2) ALARP. The study indicated that ALARP cleaning could vastly reduce IMS numbers and potential inoculum pressure and was considered the best practicable risk management outcome available.
- **Biofouling Management Plan (BFS1456)** – Outlined the proposed biofouling removal from the FLNG.
- **Biofouling/IMS Mitigation and Final Inspection (BFS1476)** – Final inspection report after biofouling removal in Geoje, and the assessment of the residual IMS Risk. The cleaning effort of the hull achieved a significant reduction in the number of IMS of concern and their cumulative reproductive potential. Despite residual risk, significant level of effort was applied in the in-water cleaning campaign. (Biofouling Solutions, 2017a)

Post-arrival of Prelude FLNG in the Operational Area (July 2017) until December 2019, there have been four ROV surveys and one set of eDNA sampling conducted, with data reviews from the biofouling experts. The updated residual risk assessment was developed in consultation with IMS agencies (i.e. DPIRD, NT Fisheries, DAWR) after the first post-arrival ROV survey to agree on an aligned approach to managing IMS risk and the ongoing adaptive IMS risk management process. The Prelude Biosecurity Management Plan is updated upon new information and understanding of the IMS residual risk.

- **Prelude ROV Inspection Report (BFS1499) -** the IMS Inspector noted the presence of S. clava, C. intestinalis, suspected C. gigas and D. vexillum persisting amongst inaccessible and/or uncleaned areas. IMS of concern which had been detected during previous inspections or any additional IMS of concern which maybe present within Korean waters, remained undetected. The Didemnum sp. present resembled D. perlucidum, the introduced colonial ascidian to Western Australia. This is not surprising considering the species were confirmed on two other installations in the area (i.e. the ROV survey and physical sample results post arrival of the neighboring Ichthys facilities). (Biofouling Solutions, 2017b)
- **eDNA water sampling report from Trace and Environmental DNA (TrEnD) Laboratory at Curtin University** - No IMS of Concern detections in the categories 'highly probable', 'probable' or 'possible'. However, the presence of Crassostrea virginica, Mnemiopsis leidyi, Psuedo-nitzschia seriata and Gymnodinium catenatum were considered inconclusive. (Curtin University, 2018)
- **Prelude ROV Inspection interpretation (BFS1526)** – An ROV survey was conducted on the Prelude hull 12-13 November 2018. IMS expert reviewed the results and updated the specific residual risk of IMS species. Based on the Dec 2018 IMS expert review of the survey data available, individual IMS of concern's residual risk of being transmitted to high value areas or inshore waters of Australia were deemed to be Moderate or lower which corresponds to a risk ranking of Moderate in Table 9-32. (Biofouling Solutions, 2018)

- **Prelude ROV Inspection Report (BFS1629)** - An ROV survey was conducted on the Prelude hull 19 September 2019. IMS expert reviewed the results and concluded "*no IMS of concern when reviewing the footage but did observe that white colonial ascidians with a colony structure and basic morphology resembling colonial ascidians of in the genus Didemnum were widely distributed on the vessel. This group includes Didemnum perlucidum which is considered an invasive marine species but is now confirmed to be widely distributed throughout Western Australian coastal waters*." Although the species is no longer considered a noxious fish in Western Australian waters with the exception of the Montebello Islands. (Biofouling Solutions, 2019)

9.8.3 Description and Evaluation of Impacts and Risks

A range of environmental sensitivities within the following groups may be at risk from the introduction of potential IMS, including:

- Biological Environment
- Socio-economic environment.

Potential risks associated with IMS establishment as a result of the petroleum activities are discussed below.

Biological Environment

Benthic communities within the operational area are characterised by low density epibenthic communities of deposit and filter feeders on bare sediments. The seabed within the entire Operational Area does not receive sufficient sunlight to support benthic primary producer habitat, such as macroalgae and zooxanthellate corals. Very few potential IMS identified can credibly survive in the water depths of the Operational Area. For example, the non-oceanic species identified in the Australian Marine Pest Monitoring Manual (Department of Agriculture, Fisheries and Forestry 2010) indicated very few IMS (aside from planktonic oceanic species such as dinoflagellates) could credibly survive in the Operational Area; only three (European clam, soft-shell clam and Northern Pacific sea star) were identified as potentially surviving in > 90 m water depth; none were identified as credibly surviving at > 200 m water depth. These three species are typically found in shallower, coastal waters. The Operational Area is all > 200 m water depth. In the highly unlikely event these species were introduced into the Operational Area, they are unlikely to survive or become established on natural substrate due to the water depth alone.

With the stated controls in place, the likelihood of introduction of IMS associated with the Crux riser tie-in or other specific vessel-based campaigns is considered extremely remote as the potential vectors (e.g. support vessels) will typically be near the FLNG for relatively short periods (up to a week). Further, general support vessels will typically be sourced from Australian waters; Australian ports are generally considered to pose a low risk of harbouring potential IMS compared to ports in other countries in the region (e.g. Indonesia and Singapore).

The waters associated with benthic communities (shoals, banks reefs and island surrounds), some KEFs (e.g. ancient coastline), WA mainland coastline and some of the Commonwealth Marine Environment in the wider region are typically shallower than those of the Operational Area. As outlined above, most potential IMS require shallower habitats than those found in the Operational Area. Hence, these shallower habitat waters in the region may be more vulnerable to introduction of IMS, however it is completely dependent on the extremely rare event of subsequent transport by support vessels.

Browse Island is located some 40 km south-southeast of the Operational Area. Although not part of the petroleum activity, support vessels may spend some time during cyclone season or inclement weather to seek shelter near Browse Island (or other banks, shoal or islands in the area) for safety reasons. With the stated controls in place to minimise potential IMS risk, direct introduction of IMS to a shoal, bank or island during these short-duration and infrequent sheltering events is considered extremely remote.

Socio-economic Environment

The socio-economic receptors from IMS introduction / establishment risk are industries outside of the Operational Area such as fishing, tourism/recreation, marine protected areas or other oil and gas operators (e.g. Inpex Ichthys). The likelihood for IMS introduction, establishment and survival at or within these receptors is extremely remote with the stated controls in place.

9.8.4 Risk Assessment Summary

Table 9-32: IMS Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	N/A	N/A	N/A
Biological Environment	Major effect	A - Extremely remote	Moderate
Socio-Economic Environment	Major effect	A - Extremely remote	Moderate

9.8.5 ALARP Assessment and Environmental Performance Standards

Table 9-33: ALARP evaluation of IMS risk control measures

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	No vessels	No	Vessels are essential for supply, standby safety support, and operations.	N/A	N/A	N/A
Substitution	Only use local support vessels	No	Although the use of local vessels is preferred, there are cases when this is impracticable due to availability of specialised vessels for the activities.	N/A	N/A	N/A
Engineering	None identified	N/A	N/A	N/A	N/A	N/A
Administrative and Procedural controls	Ballast Water Management Plan and Certificate	Yes	Vessels that are intending to discharge internationally sourced ballast water within Australian waters must submit a Ballast Water Report through Maritime Arrivals Reporting System (MARS) at least 12 hours prior to arrival to gain DAWR clearance. The acceptable area for a ballast water exchange between an offshore oil and gas installation and an Australian port is in areas that are no closer than 500 m from the offshore installation and no closer than 12 NM from the nearest land and in water at least 50 m deep. Ballast tank sediment must be disposed of in an area outside 200 nautical miles from the nearest land, and in at least a depth of 200 metres, or at an approved land-based reception facility.	6.1	Vessels coming from overseas will have required DAWR clearance including the Ballast Water Certificate and Ballast Water Management Plan if the vessel is required to discharge ballast in Australian waters. All vessels (incl. domestic) shall have a Ballast Water Management Plan in place consistent with the IMO Ballast Water Convention's Guideline.	Records of the Maritime Arrivals Reporting System (MARS) or equivalent demonstrate the vessel has sufficient DAWR clearance to operate within the Operational Area and Australian Territorial Waters. Vessel Ballast Water Management Plan Vessel Ballast Water Certificate

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			The Biosecurity Act 2015 requires that vessels have a Ballast Water Management Certificate and Ballast Water Management Plan (BWMP), and undertake reporting and management of ballast in accordance with the Act. The BWMP must: • be vessel specific (vessel name and International Maritime Organization (IMO) number) • be approved by a survey authority, recognized organisation, or the vessel's flag administration • nominate the rank(s) of the responsible officer and crew • contain the ballast water management method and pumping rates. BWMPs should be consistent with the IMO Ballast Water Convention's Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4 Guidelines). A valid Ballast Water Certificate must be issued by either a survey authority, classification society, or the administration of the vessel, and be in accordance with Regulation E-1 of the Ballast Water Convention.			
	Ballast water management within the Operational Area	Yes	Only low risk ballast water will be discharged within the Operational Area. Although the Prelude FLNG facility	6.2	Only low risk ballast water will be discharged	Sample ballast exchange logs for internationally sourced vessels and

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			location is classified as a suitable location for ballast exchange per the Australian Ballast Water Management Requirements i.e. will occur > 12 Nm from land and in water depths > 50m deep, no ballast water (originating from outside Australian waters) exchange will occur within the Operational Area of the FLNG. The product carriers and other international vessels will exchange their ballast before arriving at the Operational Area, therefore, they will discharge only low risk ballast water at the facility.		within the Operational Area.	offtake tankers demonstrate only low risk ballast water has been discharged within the Operational Area.
	Vessel specific Biofouling Management Plan and supporting Vessel Biofouling Risk Assessments	Yes	IMO biofouling guidelines considered 'best practice' for mitigation of transfer of invasive aquatic species to ALARP. Vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP Marine Vessel Biofouling Risk Assessments aligned with National Biofouling Guidelines for the Petroleum Production and Exploration Industry are carried out. If a vessel check does not result in low risk, an IMS expert will be engaged to review risk assessment and recommend mitigation measures to implement for the vessels risk to be acceptable. In order for the Prelude FLNG to maintain Low Risk Biosecurity Status, the facility should not be exposed to	6.3	Carry out the required Marine Vessel Biofouling Risk Assessments aligned with National Biofouling Guidelines for the Petroleum Production and Exploration Industry – for vessels originating from overseas or vessels being shared between operators.	Prelude Biosecurity LOW risk status from DAWR Vessel Low Risk Biosecurity Status Biofouling Risk Assessments for vessels operate within Prelude Safety Zone.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			conveyances or vessels which are considered as high risk or under biosecurity control. As such, all contracted vessels will strive to obtain low risk biosecurity status, otherwise, they will not be able to interact with the FLNG. The following FLNG-to-vessel interactions are exempted from this exposure: • Offloading of products (ex. LNG, condensate, diesel) via the offloading arms or hoses. • Offloading of equipment from another vessel onto the FLNG, but the equipment will be deployed directly to the seabed. • Transfer of pilots to support vessels during pilotage of product offtake tankers.			
Administrative and Procedural controls	Conduct IMS survey on the Prelude Hull and associated sampling of potential IMS species.	No	Existing survey data provides sufficient certainty of status of IMS risk on the FLNG. The financial and potential H&S costs of conducting dedicated physical sampling of potential IMS is considered grossly disproportionate to the benefit in carrying out such a survey where the gain in terms of overall risk reduction is negligible. Four ROV surveys (and one eDNA sampling event) were conducted on the Prelude FLNG hull between 2017 and 2019. The surveys were reviewed by independent IMS expert and concluded	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			no IMS of concern on the Prelude Hull since arrival in field in 2017.			
	eDNA water sampling within Ports visited by vessels going to and from the Operational Area	No	eDNA analysis of water samples from the port will be inconclusive as to whether the risk has originated from the petroleum activities due to the number of users of the port. As agreed by the State marine biosecurity agencies, this is the responsibility of the State agencies.	N/A	N/A	N/A
	Further investigation of biology, method of reproduction, propagule pressure/competency periods and behaviour, ability for adults to depart the FLNG, oceanic currents, interaction with vessels and domestic ports	No	The biology of each species needs to be considered to determine the likelihood of the species reproducing, spreading and contaminating both nearby and distant sensitive receptors and/or anthropogenic structures. This might involve investigating each species' methods of reproduction (e.g. sexual and asexual), potential larval/propagule pressure based on assessed abundance and density witnessed on the Prelude FLNG, larval/propagule competency periods and behaviour, ability for adults and/or fragments to depart the vessel, strength, direction and prevailing oceanic currents, interaction with domestic conveyances, and their interaction with domestic ports of Australia. Such an assessment is complex, time-consuming and will suffer from significant knowledge gaps/uncertainty.	N/A	N/A	N/A
	In-water cleaning of the FLNG's hull	No	Limited availability of suitable cleaning methodology – Only two cleaning methodologies have been approved by	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			the paint/coating provider for the Prelude FLNG: caviblaster and robotic/ROV cleaner provided by Samsung Heavy Industry. Other technologies have been considered and tested in Geoje (South Korea), but were determined not to be suitable as they will damage the coating, therefore, voiding the intended functionality of the coating and the warranty. The robotic/ROV cleaner can only access flat areas, but will not be able to clean the niches. The caviblaster will require divers. Not all areas can be cleaned by the ROV cleaner, and divers will be required which present a significant safety exposure (diving in an offshore environment, and under a weather vaning facility). The indicative total cost would likely be more than $10 million per cleaning activity. This cost is grossly disproportionate to the benefit gained as any in-water cleaning approach does not give certainty to the removal of all potential IMS. Cleaning will also result in disruption to operations in order for the sea-chest gratings to be cleaned as water intakes have to be shutdown which will cause disruption to normal seawater supply into the facility. Therefore, in-			

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			water cleaning may result in considerable operational disruption which will result in significant costs. As there will always be residual risk of IMS even after in-water cleaning (regardless of any cleaning technology used or even if the removed biofouling are contained) and this has been deemed as acceptable under the Shell risk assessment methodology, there is therefore limited benefit of in-water cleaning at such a grossly disproportionate cost and safety risks. Therefore, in-water cleaning is not considered ALARP.			
	Develop specific IMS response plans and carry out training and drills to prepare for the need to respond to an IMS incident	No	The resources and time that would be needed for a mitigative control such as this is significant and considered grossly disproportionate to the benefit gained since the time it would take to prepare a response plan in the event of an incident is not considered to be significant in the context of breeding and reproductive cycles of most potential IMS species. Furthermore, IMS response plans are planned to be developed by government as outlined in the National Strategic Plan for Marine Pest Biosecurity 2018-2023.	N/A	N/A	N/A

9.8.6 Acceptability of Impacts and Risks

Table 9-34: Acceptable Levels of Risks from IMS

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Benthic communities	No impacts to high-value sensitive benthic communities.	Yes	The introduction of an IMS as a result of the Prelude operations is unlikely to survive given the water depth in the Operational Area. While surrounding shallower habitats in the wider region are likely to be more susceptible to an IMS becoming established due to their relatively shallow depth, the nearest receptor to Prelude is approximately 40km away (Browse Island) which makes the likelihood of an IMS becoming established in the region extremely remote. Shell will take industry-standard measures to reduce the likelihood of an IMS being introduced as a result of petroleum activity. If an IMS were to be become established, it would be very difficult to eliminate, however there is an extremely remote likelihood of significant impacts to the identified potential receptors.
	KEFs	No impacts to environmental values of KEFs	Yes	
	Commonwealth Marine Environment	No significant impacts to the Commonwealth Marine Environment (Refer to Table 8-1).	Yes	
	WA Mainland Coastline	No impacts to mainland coastline.	Yes	
Socio-economic and Cultural Environment	Marine Protected Areas	No impacts to ecological values of Marine Protected Areas	Yes	Based on ongoing controls, the likelihood of an IMS becoming established is extremely remote. Shell will take industry-standard measures to reduce the likelihood of an IMS being introduced as a result of petroleum activity.
	Fishing Industry	No negative impacts to exploited fisheries resource or aquaculture stocks which result in a demonstrated direct loss of income or other benefits.	Yes	
	Tourism and Recreation	No negative impacts to nature-based tourism resources	Yes	

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
		resulting in demonstrated loss of income.		

The assessment of risks from IMS determined the residual rankings of Moderate or less (Table 9-35) which is deemed as acceptable with the stated controls in place. As outlined above, the acceptability of the risks from the introduction of IMS associated with the petroleum activities has been considered in the context of:

Principles of ESD

The inherent risks from the introduction of IMS resulting from the petroleum activities are inconsistent with some of the principles of ESD based on the following:

- The introduction of an IMS poses a risk to the diversity and ecological integrity of the biological and socio-economic environments in the vicinity of the Operational Area and the wider region.

However, Shell will apply a range of controls to ensure that the risk of IMS introduction is reduced to a level that is acceptable and ALARP. Following successful application of these controls, Shell considers the residual risk to be consistent with the principles of ESD.

Relevant Requirements

Management of the risks from an introduction of IMS resulting from the Prelude project are consistent with relevant legislative requirements, including:

- compliance with international maritime conventions, including
  - The International Convention for the Control and Management of Ships' Ballast Water and Sediments
  - The International Convention on the Control of Harmful Anti-Fouling Substances
  - IMO 2011 Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species.
- compliance with Australian legislation and requirements, including:
  - Protection of the Sea (Harmful Anti-fouling Systems) Act 2006:
    - Marine Order 98 – Marine Pollution prevention – anti-fouling systems.
  - Biosecurity Act 2015:
    - National Biofouling Management Guidelines
    - Australian Ballast Water Management Requirements.
  - NT Fisheries Act
  - WA Fish Resources Management Act 1994, subsequent Fish Resources Management Regulations 1995 and the Aquatic Resources Management Act 2016
  - the WA DPIRD Biofouling Biosecurity Policy.

Matters of National Environmental Significance

Threatened and Migratory Species

The policies, strategies, guidelines, conservation advice and recovery plans for MNES that may occur within the potential area affected by an IMS do not identify IMS as a threat.

Commonwealth Marine Environment

The impacts and risks from the introduction of IMS will not result in significant impacts to the Commonwealth Marine Environment.

Table 9-35: Summary of Alignment of the Risks from the IMS Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Threats Relevant to the Project	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	N/A	N/A	N/A
Commonwealth Marine Area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	Introduction of IMS	The residual risk assessment indicates that the petroleum activities will not exceed the Commonwealth marine environment significant impact criteria provided in Table 8-1.
Wetlands of International Importance	N/A	N/A	N/A

External Context

Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking the assessment of impacts and risks.

Ongoing monitoring and engagement with Relevant Persons for IMS will be carried out in accordance with the process below established in agreement with the Relevant Persons Figure 9-7.

The following claims were made by DPIRD regarding controls to consider:

- Suggest support vessels which aligns with proposed “NOPSEMA Offshore Support Vessel Reference Case” process. – Shell to consider once finalized.
- IMO biofouling guidelines considered ‘best practice’ for mitigation of transfer of invasive aquatic species to ALARP – Shell has adopted this.
- Suggest supporting vessels encouraged to have vessel specific (as per IMO guidance) Biofouling Management Plan (BMP) and Biofouling Record Book (BRB) recording implementation of BMP. – Shell has adopted this.

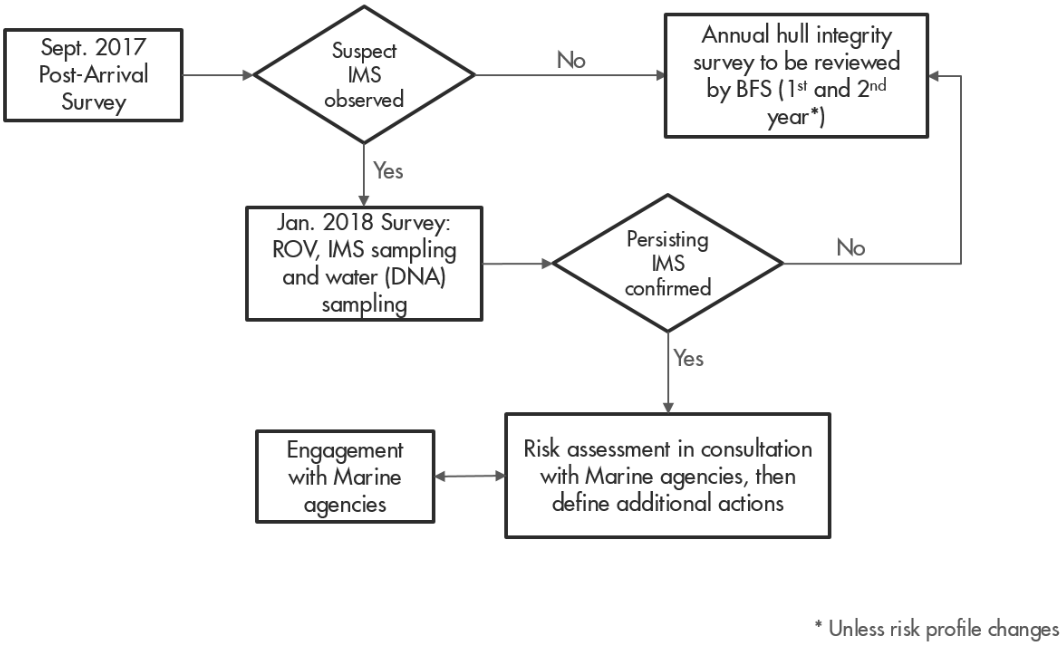

Figure 9-7: Ongoing IMS Monitoring and Adaptive Management Plan (as agreed with IMS agencies during workshop end 2017, extracted from Prelude FLNG Biosecurity Management Plan)

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of risks from IMS determined the residual risk rankings were Moderate or lower (Table 9-35). As outlined above, the acceptability of the impacts and risks from IMS associated with Prelude Field has been considered in the context of:

- The established acceptability criteria for the IMS aspect of the Prelude field
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Given the considerable water depth (>200m), potential IMS species which may be present on Prelude FLNG would not able to settle and establish on the available natural substrate within the Operational Area and the nearest shallow water sensitive receptor, Browse Island, is located approximately 40km away. Considering all of the controls which are in place, the residual risk of potential species of IMS persisting on Prelude FLNG, spreading, attaching to support vessel hulls and establishing at ports following a long distance vessel transit is Moderate given the potential consequences following the very remote likelihood of establishment.

Shell considers residual risks of moderate to be acceptable with controls if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the IMS aspect of the petroleum activities.

Based on the points discussed above, Shell considers the risks from IMS associated with the petroleum activities to be acceptable.

9.8.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No IMS established in the natural environment (beyond the FLNG and installed project infrastructure) as a result of the petroleum activities.	No confirmed and externally reported instances of IMS establishment in the natural environment as a result of the petroleum activities.

9.9 Discharge of Liquid Effluent

A range of aspects of the Prelude petroleum activities will result in the discharge of liquid waste streams to the marine environment. These aspects include:

- Drainage and bilge effluent
- Food waste, greywater and sewage
- Cooling Water (CW)
- Desalination brine, boiler blowdown and Mixed Bed Polisher (MBP) Effluent
- Produced Water (PW)
- Use and release of chemicals in ad-hoc discharges.

Descriptions of the characteristics of each of the routine liquid discharge streams are summarised in Table 9-36 and further detailed specifically in Section 9.9.1 below. Note that unplanned spills, e.g. of chemicals or hydrocarbons, are considered separately in Section 9.14.

Table 9-36: Types, location, source depth, discharge depth, flow rates and orientations of the planned and routine liquid discharges from Prelude FLNG

Discharge Port Name	Discharge Type	Port or Starboard	Source Depth Below Sea Level (BSL) (m)	Typical Discharge Depth BSL (m)	Orientation	Maximum Estimated Flowrate (m^3/hr)
P47	Sewage	Port	N/A	11.5	Vertical	0.17-0.43 (Continuous)
						20 (Batch)
P50	Grey Water	Port	N/A	11.5	Vertical	2.4-2.7
P50	Foodwaste	Port	N/A	11.5	Vertical	0.01-0.03

Discharge Port Name	Discharge Type	Port or Starboard	Source Depth Below Sea Level (BSL) (m)	Typical Discharge Depth BSL (m)	Orientation	Maximum Estimated Flowrate (m^3/hr)
P6	Produced Water	Starboard	N/A	5	Horizontal outboard	50-165
P51	SW1 CW Discharge	Port	Near Surface	12.1	Vertical	142
P60	SW1 CW Discharge	Starboard	Near Surface	13	Vertical	142
P61	SW1 CW Discharge	Starboard	Near Surface	12.6	Vertical	142
P53	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P54	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P63	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P64	SW2 CW Discharge	Starboard	150	5.4	Horizontal to stern	14000
P48	SW3 CW Discharge	Starboard	Near Surface	17.2	Vertical	4028
P49	SW3 CW Discharge	Port	Near Surface	17.2	Vertical	4028
P35	SW4 CW Discharge	Port	Near Surface	6.2	Horizontal Outboard	1750
P36	SW4 CW Discharge	Port	Near Surface	6.2	Horizontal Outboard	1750
P37	SW4 CW Discharge	Port	Near Surface	6.4	Horizontal Outboard	1750
P59	Desalination Brine	Starboard	N/A	12	Vertical	1100
P30	Boiler Blowdown	Starboard	N/A	18.5	Vertical	14-30
P38	MBP Effluent	Port	N/A	12	Vertical	200
P62	Drainage effluent	Port	N/A	11.5	Vertical	15.8
P39	Bilge	Starboard	N/A	19	Vertical	18

9.9.1 Aspect Context

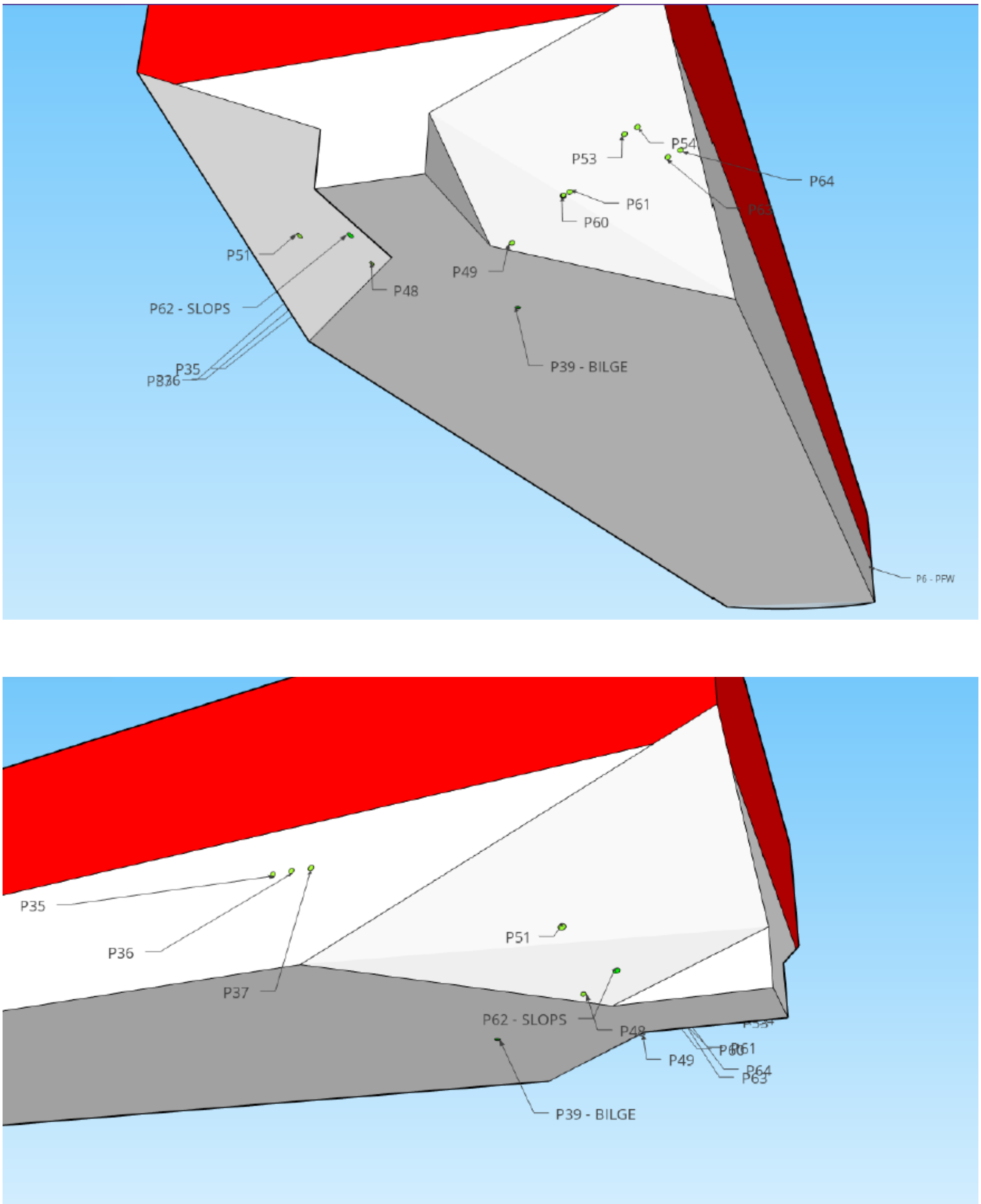

Figure 9-8: Locations of all routine planned liquid discharges on the Prelude FLNG. Numbers correspond with those in Table 9-36

9.10.1.1 Drainage (Slops) and Bilge Wastes

Marine Support Vessels

Deck drainage and bilge from Marine support vessels consists mainly of wash down water, seawater spray and rainwater and may contain small quantities of oil, grease, metals, detergents (surfactants) and other residual chemicals present on the deck, which has the potential to create surface sheens and short term, localised reduction in water quality if it enters the marine environment.

FLNG

The FLNG Open Hazardous Drainage System collects and disposes both deck drainage (e.g. rain water), potentially oil contaminated streams (e.g. deluge water, accidental spills, and cleaning water during maintenance activities) as well as continuous process drainage streams (e.g. automatic filter backwash, analyser conditioning systems). When there is deck drainage, the inputs into the majority of inputs into the Open Hazardous Drainage system originates from continuous process drainage sources (~200m^3 per week). All open hazardous drainage sources is directed to the Open Drain Tanks and then Slops Tanks where it is treated by gravity separation prior to discharge. The Slops Tanks can also act as a further separation mechanism for managing Produced Water.

Unlike other LNG facilities, the Prelude FLNG facility has a machinery space and thrusters. Similar to regular trading vessels, run-off from this area is collected in the Bilge System and treated prior to being discharged using a unit designed to meet MARPOL limits.

Runoff from deck areas containing LNG, Mixed Refrigerant (MR) or LPG is not contained to ensure that cryogenic spills are not left in-situ to develop into flammable gas clouds on the facility. This is a design safety measure. In the unlikely event of a spill, the liquefied hydrocarbons would change into a gaseous phase rapidly with minimal effect on the marine environment. Therefore, in areas where potential cryogenic spills can occur, Entirely Oil Free (EOF) streams of storm-water, sea spray and water generated from routine operations such as deck and equipment cleaning and fire drills are not collected and contained. To protect the environment from potential spills during maintenance of hydrocarbon containing equipment in cryogenic areas, spill equipment is stored onboard the facility to enable the establishment of temporary containment facilities.

The closed drain system will not have any liquids discharged to the ocean, therefore, there are no risks or impacts associated with the closed drains systems.

The FLNG's drainage system is further described in Appendix A: Detailed Facility Description.

9.10.1.2 Food Waste, Sewage and Greywater

Vessels

Vessel activities within the Operational Area will require planned discharges that will likely include sewage, greywater and food waste. Typical discharge volumes per vessel type are provided in Table 9-37. These volumes are indicative only and are provided for the purposes of the corresponding impact assessment and may vary.

FLNG Facility

The sewage system on the FLNG facility collects black water, some greywater and sweat drains from the following prior to discharge:

- Accommodation
- Hospital
- Toilets in the aft machinery space.

The pumps and screens within the vacuum toilet and sewage collection system effectively reduces sewage particles to <25mm. There is a sewage holding tank which was designed to hold sewage if not appropriate to discharge overboard.

The grey-water system processes the effluent stream from sinks, washbasins, showers, laundry and sweat drains. Drains from the galley sinks are routed to the grey-water system. Grey water quantity is greater than black water and can be managed separately if required. Grey water can be discharged directly overboard or overboard via the grey water tank.

The food waste system includes a macerator, which discharges to the ocean.

The expected production and release rates of sewage, greywater and food waste for the FLNG and typical vessels are shown in Table 9-37. These estimates are based on the anticipated upper bound, assuming peak manning and all listed vessels in the Operational Area at the same time which is highly unlikely.

Table 9-37: Upper bound estimates of sewage, grey water and foodwaste volumes and associated calculated nutrient input estimations into the marine environment

Vessel/Facility	Typical Max POB	Estimated Sewage volume (m^3/day)[1]	Estimated Greywater Volume (m^3/day)[2]	Estimated Food Volume (kg/day)[3]	Estimated Total Nitrogen (TN) Load (kg/day)[4]	Estimated Total Phosphorus (TP) Load (kg/day)[5]
FLNG	340	10.2	57.8	340	Sewage: 1.02 Greywater: 1.52 Food waste: 8.16 Total: 10.70	Sewage: 0.09 Greywater: 0.58 Food waste: 1.36 Total: 2.03
Supply Vessel	68	2.0	11.6	68	Sewage: 0.20 Greywater: 0.30 Food waste: 1.63 Total: 2.14	Sewage: 0.02 Greywater: 0.12 Food waste: 0.27 Total: 0.41
Infield Support Vessel	10	0.3	1.7	10	Sewage: 0.03 Greywater: 0.04 Food waste: 0.24 Total: 0.31	Sewage: 0.003 Greywater: 0.02 Food waste: 0.04 Total: 0.06
Installation Vessel (e.g. for Crux tie-in)	120	3.6	20.4	120	Sewage: 0.36 Greywater: 0.54 Food waste: 2.88 Total: 3.78	Sewage: 0.03 Greywater: 0.21 Food waste: 0.48 Total: 0.72
Accommodation Vessel (e.g. Major Maintenance Campaign)	650	19.5	110.5	650	Sewage: 1.95 Greywater: 2.91 Food waste: 15.6 Total: 20.46	Sewage: 0.17 Greywater: 1.12 Food waste: 2.6 Total: 3.88

Vessel/Facility	Typical Max POB	Estimated Sewage volume (m^3/day)[1]	Estimated Greywater Volume (m^3/day)[2]	Estimated Food Volume (kg/day)[3]	Estimated Total Nitrogen (TN) Load (kg/day)[4]	Estimated Total Phosphorus (TP) Load (kg/day)[5]
Total Upper Bound (Rounded)					**37**	**7**

1. Calculated based on 0.03m3 per person/per day
2. Calculated based on 0.17m3 per person/per day (USEPA 2011)
3. Calculated based on 1kg per person/per day
4. Conservatively assumes no consumption via vessel treatment systems. Calculated based on sewage discharge of 100 mg/L TN for sewage (Washington State Department of Health 2005), 26.3 mg/L for greywater (USEPA 2011) and 2.4% TN for food waste (Polglaze 2003).
5. Conservatively assumes no consumption via vessel treatment systems. Calculated based on sewage discharge of 8.6 mg/L TP for sewage (State of Idaho Department of Environmental Quality 2012), 10.1 mg/L for greywater (USEPA 2011) and 0.4% TP for food waste (Polglaze 2003).

9.10.1.3 Cooling Water

Vessels

Based on relatively low predicted volumes of cooling water discharged from vessels coupled with expected rapid dilution and dispersion, these discharges are not considered to present credible impacts to receptors and are not described further.

FLNG

Seawater is used as a heat exchange medium for the cooling of machinery engines and in the production process. Seawater is drawn from the ocean and flows counter current through closed circuit heat exchangers, transferring heat from the machinery or production process to the seawater via an intermediate circulating freshwater system. Seawater is then discharged to the ocean at an average of approximately 5°C to 9°C above the ambient seawater temperature (depending on season and the depth it is drawn from).

The Prelude FLNG facility has 12 cooling water discharge outlets which are situated below the water line towards the stern of the facility. They differ by flow rate and orientation as shown in Table 9-36 and Figure 9-8. The total throughput of cooling water during normal operations is approximately 80,000 m^3/h.

Chlorine in the form of sodium hypochlorite, produced through the Electrochlorination Unit (ECU), is added to the cooling water to reduce the potential for marine growth within the pipework of the cooling water system. As such there is typically residual (free) chlorine levels at a targeted concentration of 0.2 mg/L at the point of cooling water discharge during continuous dosing. However, it is anticipated that during shock dosing (at random times but on average 1hr per day), there may be short-term increases in discharge concentrations of up to approximately 0.6 mg/L. Shock dosing at higher concentrations is used in addition to continuous dosing at regular intervals to provide further protection against biofouling of internal pipework before organisms have an opportunity to become resistant, establish and grow under lower continual concentration conditions. Cooling is required for the FLNG facility from a safety and technical integrity critical perspective as part of the hydrocarbon production process. Therefore maintaining a system that is free of internal marine fouling is absolutely integral to the safe and efficient operation of the facility.

9.10.1.4 Desalination Brine and Mixed Bed Polisher Effluent

The production of freshwater from seawater in the seawater distillers on the FLNG facility results in a discharge of seawater with a slightly elevated salinity (approximately 10% higher than seawater). The volume of the discharge is dependent on the operational demand for fresh (or potable) water. Standard demand for freshwater for the FLNG facility will be approximately 70 m^3/hr, however this may be up to about 120 m^3/hr during major maintenance activities or other campaigns, which require a greater number of people to be located at the facility for short periods of time. Chlorine scavenging, scale inhibiting and/or small volumes of other treatment chemicals may be present in the waste stream at low concentrations.

Mixed Bed Polisher (MBP) effluent discharge is a batch discharge, characterised in Table 9-36 and location shown within Figure 9-8. The discharge typically managed to pH 6-12 and is generated from the requirement to regenerate the mixed bed polishers to ensure their reliable operation.

The boiler blowdown discharges are associated with water within the boiler system that is discharged with flashed steam as is the case for many commercial vessels that utilise marine boiler systems. The boiler blowdown discharge is a continuous discharge of approximately 2 m^3 per hour per boiler. On irregular occasions, when deposits in the boiler drums have to be removed, approximately 30 m^3 per hour may be discharged for short durations. The discharge is characterised in Table 9-36 and location shown within Figure 9-8. The discharge typically is managed to a pH between pH 9-12 and also contains residual chemical additives which are used to prevent corrosion and scale build-up within the boilers to maintain safe, energy efficient and functional integrity.

9.10.1.5 Produced Water (PW)

PW is water which has permeated into the gas reservoir over time and includes condensed water. When the liquid and gaseous hydrocarbons are extracted from the reservoir the PW is separated from the hydrocarbon products in the inlet facilities. PW, including condensed water, is an undesirable by-product of the gas and condensate extraction process and is discharged into the marine environment directly from the FLNG following treatment. The PW discharge is located near the bow, approximately 40 m from the turret, and on the starboard side of the FLNG facilty at approximately 5 m below the water line.

The PW treatment system of the FLNG facility is designed for a maximum 165 m^3/hr discharge capacity. However, for the duration of this EP and prior to the breakthrough of the produced formation water (saline aquifer in the liquid phase), it is anticipated that discharge of condensed PW (freshwater condensed out of the gas phase through the process) will occur in batches and at a considerably lower rate of approximately 50 m^3/hr.

Hydrocarbons from the PW are treated by the Macro Porous Polymer Extraction (MPPE) Package. This system is further described in Section 6.0 and Appendix A: Detailed Facility Description. Treated water from MPPE package is then routed overboard to sea. The package is designed to discharge PW at less than 42 mg/L Total Petroleum Hydrocarbon (TPH) content instantaneous and less than 30 mg/L TPH over a 24hr average. The definition of TPH is documented in Prelude FLNG Oil in Water Measurement Philosophy (HSE_GEN_16227). A buffer tank is available to recycle and retreat PW if it is off-specification.

During initial ramp-up to the maximum flowrate for each well, including the initial production test runs at up to 200 MMSCFD production, there may also be short time periods (approximately 72-96 hours per well) where the PW discharge may contain concentrations of up to 100 mg/L TPH required to complete the well clean-up process which involves flowing the wells at 100% capacity. During these completions of the initial 'clean up' activities, it is expected each well will produce back higher rates of drilling mud.

As described further in Appendix A: Detailed Facility Description, MEG is used in the subsea system for hydrate prevention and preservation under certain scenarios. This may result in PW discharges containing up to approximately 20% MEG for short durations following these events.

9.10.1.6 Use and Discharge of Chemicals

Chemical usage is required for various routine and non-routine process and non-process applications and as such, chemicals may be present in waste water streams which are discharged to the ocean.

Chemicals are utilised on the Prelude FLNG facility, marine support vessels and associated subsea facilities for a variety of purposes and can be divided into four broad categories, as described below.

Operational Process Chemicals

An operational process chemical is the active chemical added to a process or static system, which provides functionality when injected in produced fluid, utility system streams or for treatment. These chemicals types may be present in continuous or batch discharge streams into the ocean:

- Hydrate inhibitor
- Oxygen scavenger
- Scale inhibitor
- Biocide
- Antifoam
- Demulsifier
- Reverse Demulsifier
- Hypochlorite
- Boiler Water Treatment
- Water Clarifier
- Acids e.g. Hydrochloric, citric, sulphamic
- Paraffin Inhibitor/Pour Point Depressant
- Hydraulic control fluid (subsea) - Subsea control fluids are used to open or close wellhead/subsea valves resulting in small volumes of subsea control fluids being discharged each time a valve is activated.

Environmental impact assessment of the routine planned waste streams and their respective chemical constrituents is detailed further in Sections 9.9.2 and 9.9.3 and are not addressed further in this subsection.

Facility Maintenance/Non-Process Chemicals

Facility maintenance chemicals include chemicals which are required for general maintenance activities on the FLNG facility, marine support vessels and respective equipment. These may include paints, degreasers, greases, fire-fighting foam, lubricants and domestic cleaning products. They may also include chemicals required for speciality tasks, such as laboratory testing and analysis. These non-process chemicals generally present negligible risk to the environment as they are either not usually discharged as a result of their use (e.g. paint) or are used intermittently and/or are typically only ever discharged in small volumes and/or low concentrations (e.g. domestic cleaning products, washdown cleaners or fire-fighting foam during testing).

Subsea Operation, IMR and Intervention Activity Chemical Discharges

The majority of the maintenance and intervention activities are non-intrusive visual inspections undertaken via ROV as the facilities are designed for a minimum of 25 years field life with minimal intervention. However, in the event that the certain subsea equipment needs maintenance, repair, replacement or well intervention due to failure or damage for example, the estimated associated discharge types and volumes are provided in Table 9-38.

Table 9-38: Estimated Chemical Discharge Types and Typical Volumes during Subsea Operation, IMR and Intervention Activities

Discharge Type	Estimated Discharge Per Event
Control module replacement	Approximately 4L of HT2 TransAqua Hydraulic Fluid (or similar)
Choke valve replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per valve replacement
Flow module replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per flow module
Flowline connector replacement	Approximately <1m^3 of MEG with residual produced hydrocarbon per connector
Flexible riser connector replacement	Approximately 20m^3 of MEG with residual produced hydrocarbon per connector
Riser replacement	Approximately 40m^3 of MEG with residual produced hydrocarbon per riser
Light well intervention (Refer to Section 6.4.4-6.4.5)	Approximately 3.2 m^3 MEG, residual produced hydrocarbon, freshwater and associated dosing chemicals discharged from the production trees and well intervention tooling.
Dye used for leak detection and environmental monitoring purposes	Approximately 5-50L per leak test or monitoring event
Cycling of subsea valves[1]	Approximately 0.01-11L per actuation per valve of HT2 TransAqua Hydraulic Fluid (or similar)

Discharge Type	Estimated Discharge Per Event
Hotstab activities	Approximately 0.5-10L of associated chemical in use per hotstab
Sulphamic acid (or similar alternative) used for marine growth removal or pipe treatment	For SCM replacement – Approximately 5m^3 For general inspection/ROV manipulation – Approximately <0.1m^3 per inspection point/activity
Grouting, grout bag installation and grout line flushing	Approximately 0.2m^3 per discharge

1 – Note cycling of valves and associated discharges is also a routine ongoing activity

Installation and Commissioning Activity Chemical Discharges

During installation and commissioning activities, some chemicals may be required for specific purposes and, by virtue of their use, may be intermittently discharged or have the potential to be discharged (e.g. required as a result of preservation and tie-in works) where not practicable or considered ALARP to recover and reprocess offshore or transport onshore. MEG, freshwater, storage/preservation fluids and associated dosing chemicals (e.g. oxygen scavenger, biocide and dye) may be discharged from the Prelude FLNG facility and subsea facilities for short periods and in relatively low volumes during future installation and commissioning activities.

During leak-testing, installation works, make-and-break of subsea connections, subsea intervention works and the use of ROV, some disbursement of liquids may occur. This includes, but is not limited to, the following activities detailed in Table 9-39.

Table 9-39: Estimated Discharges Types and Volumes During Future Installation and Commissioning Activity

Discharge Type	Estimated Discharge Per Event
Leak testing of future risers e.g. Crux export pipeline riser	Future risers will be filled with preservation fluid and dye during pull in and laying – either MEG or chemically treated water. Riser volumes are approximately 130m^3 and it is estimated that approximately 4m^3 of this may be discharged when making connection to the test skid due to loss of the static head. After leak testing it is anticipated that approximately 3m^3 may be discharged as part of the de-pressurisation activity.
Leak testing of future umbilicals (e.g. Crux dynamic umbilicals)	Future dynamic umbilicals will be filled with hydraulic fluid or preservation fluid (e.g. MEG) and dye. Dynamic umbilical volumes are approximately 2m^3 and it is estimated that approximately 1m^3 of this may be discharged per umbilical when making connection to the test skid due to loss of the static head. After leak testing it is anticipated that approximately 1m^3 may be discharged as part of the de-pressurisation activity.

Discharge Type	Estimated Discharge Per Event
Contingency flushing (e.g. due to seawater ingress into riser or umbilical during preservation period)	Approximately 260 m^3 per riser and 3m^3 per umbilical of either treated MEG or water dosed with a combination of biocide, oxygen scavenger and dye.
Tie-in to future risers, e.g. connection of Crux export pipeline to riser	Future risers will be filled with preservation fluid during pull in and laying – either MEG or chemically treated water and dye. Riser volumes are approximately 130m^3 and it is estimated that approximately 4m^3 of this may be discharged when making connection due to loss of the static head.
Tie-in to future umbilicals, e.g. connection of Crux umbilicals	Future dynamic umbilicals will be filled with hydraulic fluid or preservation fluid (e.g. MEG). Dynamic umbilical volumes are approximately 2m^3 and it is estimated that <1m^3 of this may be discharged per umbilical when making connection due to loss of the static head.
Acid (e.g. sulphamic, citric or hydrochloric) used for marine growth removal	Approximately 2-3m^3 for removal of marine growth prior to undertaking the activity e.g. if marine growth is found at the bottom of the turret hindering access for the riser and umbilical pull-in.

A number of other planned liquid discharges may occur during the project life, including hydraulic fluids from ROVs or other underwater equipment, downline flushing (e.g. grout and/or hotstab lines during IMR campaigns), lubrication fluids from planned maintenance of the subsea system, fluids from IMR activities such as coatings repair, hydrotest fluids and others from time to time. These discharges are expected to be for short durations, infrequent and/or relatively minor in nature and scale and any potential impacts of such discharges are expected to occur within the area influenced by the larger planned discharges described in this section and are unlikely to result in impacts to the environment that are not already assessed within this EP.

It is impractical to forecast exact types and volumes of all required liquid discharges for potential future activities throughout the facility lifetime and therefore Table 9-38 and Table 9-39 are indicative only for the purposes of this impact assessment.

9.9.2 Description and Evaluation of Impacts

Planned liquid discharges to marine waters creates a potential for the localised decline in water and sediment quality and for biota in those environments to be exposed to physical characteristics and contaminants at concentrations that may cause acute or chronic effects.

The identified effect pathway associated with the planned liquid discharges can be summarised by the following:

- Changes to physical and/or chemical water quality resulting in:
  - Impacts to sensitive biological receptors.

Any effects on water quality are expected to be within the surface layers only and have no effect on or damage to seabed/benthic receptors (refer to Section 9.10.2.2 Biological Environment for further details).

The magnitude and sensitivity of any impacts on the identified sensitive receptors varies according to multiple factors, including discharge composition, plume dilution/dispersion, bioavailability, duration of exposure and marine species physiology and behaviour. A detailed description and evaluation of these impacts is provided in the subsections below. A summary presenting credible interactions associated with the various liquid discharges is provided in Table 9-40 assessed per environmental receptor category. Where credible interactions have been identified these have been discussed in further detail in the subsequent impact assessment sections and are broken down further into receptor sub-category where relevant. The subsequent impact assessment also provides justification on why certain receptors, e.g. sediments and benthic habitats, have been assessed as having no credible interaction and/or where no environmental damage or effects have been identified for the duration of this EP.

Table 9-40: A matrix summarising credibility of interactions with the identified environmental receptors from the various planned liquid discharge streams

	Drainage (Slops) and Bilge	Sewage, Greywater and Food Waste,	Cooling Water	Brine, Boiler Blowdown and MBP Effluent	Produced Water	Ad-Hoc Discharges
Water Quality	✓	✓	✓	✓	✓	✓
Sediment Quality	×	×	×	×	×	×
Benthic Communities	×	×	×	×	×	×
Pelagic Communities	✓	✓	✓	✓	✓	✓
KEFs	×	×	×	×	×	×
Threatened Ecological Communities	×	×	×	×	×	×
Ramsar Wetlands	×	×	×	×	×	×
Commonwealth Marine Area	✓	✓	✓	✓	✓	✓
WA Mainland Coastline	×	×	×	×	×	×
Threatened and Migratory Species	×	✓	×	×	×	×
Heritage	×	×	×	×	×	×
Marine Protected Areas	×	×	×	×	×	×
Fishing Industry	×	×	×	×	×	×
Tourism and Recreation	×	×	×	×	×	×
Defence	×	×	×	×	×	×
Shipping	×	×	×	×	×	×
Indonesian Coastline	×	×	×	×	×	×
Oil and Gas Industry	×	×	×	×	×	×

×	**Interaction Assessed as Non-Credible and/or No Environmental Damage or Effects**
✓	**Interaction Considered Credible - Discussed Through Relevant Impact Assessment Sections Below**

9.10.2.1 Physical Environment

Drainage (Slops) and Bilge Effluent

Open Drainage (slops) and bilge waste discharges are intermittent discharges which can result in water quality changes immediately surrounding the discharge point, with the spatial extent of changes to water quality remaining very localised. It is recognised that there may be various minor quantities of metal and chemical constituents that may not be captured as a part of the oil treatment systems associated with the open drains and bilge systems outlined in Appendix A: Detailed Facility Description and onboard support vessels. This may result in the discharge of minor quantities of diluted toxicants into the ocean which may cause localised and temporary reductions in water quality. Overall, the residual impact of the discharge of open drainage and bilge effluent to water and sediment quality is considered of slight impact consequence (Magnitude – 1, Sensitivity – L).

Food Waste, Sewage and Greywater

Discharge of sewage, greywater and foodwaste into the marine environment may impact on water quality, including eutrophication, increased turbidity, increased pathogens (bacteria, viral agents and/or parasites), and increased biological oxygen demand, with the associated impacts on marine biota as discussed further in Section 9.10.2.2 Biological Environment below. These discharges can contain a variety of substances typically at very low concentrations, including oil/grease, some organic compounds, detergents, metals, suspended solids, chemicals, personal hygience products and pathogens.

Discharges of food waste, sewage and grey water can cause some temporary localised nutrient enrichment of the surface waters around the discharge point and have the potential to attract marine fauna that feed on the particulate material. Such low volume outputs of nutrients relative to the receiving environment presents no environmental damage or effects to water quality associated with eutrophication, increased BOD and/or decreased dissolved oxygen concentrations. The BOD of the sewage, greywater and food waste effluent is unlikely to lead to oxygen depletion of the receiving waters as highly oxygenated receiving waters will rapidly assist with oxygenation of the discharge in such a dynamic offshore environment.

At a discharge release depth of >11 m, the positively bouyant sewage and greywater effluent plumes are typically heavily diluted by the time they reach the surface of the water column. Therefore no detectable impacts to marine sediment quality are forecast for sewage or grey water due to the significant water depth, bouyant nature of the plumes and highly dispersive and dilutive environment. For food discharges, based on biodegradability and water depth in the open-ocean currents, the discharges are expected to be rapidly diluted and dispersed by the open-ocean ambient currents, with no detectable impacts to marine sediment quality predicted.

In 2008, Woodside conducted monitoring of 10m^3 of sewage discharged at distances of 50m, 100m and 200m downstream of a platform and at five different water depths over a period of 24 hrs (Woodside 2008). This monitoring confirmed that discharges of macerated sewage were rapidly diluted or nutrients rapidly metabolised. No elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. This Woodside monitoring scenario is conservative when compared to the Prelude case because Prelude's movement around the turret and the sewage discharge point being near the back of the hull (more turbulent) will lead to more mixing of the sewage discharged.

The Woodside (2008) study demonstrated that a 10 m^3 sewage discharge over 24 hrs from a stationary source in shallow water, reduced to approximately 1% of its original concentration within 50 m of the discharge location. In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted or nutrients rapidly metabolised and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. As sewage discharge from the FLNG facility is ~10m^3/day as well, this study provides confidence to the residual impact ranking given the deep water and highy dispersive offshore environment where the Operational Area is located.

Given the volume and properties of the discharged effluent which are highly biodegradable, low toxicity and low persistence, the rapid dilution in the open ocean environment, localised impact area, and distance from the nearest value (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island ~40km away), the residual impact cosequence to water quality is assessed as slight (Magnitude -1, Sensitivity – L).

Cooling Water

The effect of chlorine and chlorine breakdown products in cooling water discharges have been the subject of many studies, generally through toxicity testing. Chlorine is a strong oxidant and following discharge and dilution, the residual (free) chlorine quickly reacts with inorganic constituents such as sodium, iron (II), nitrite and sulphide to produce chlorides (such as NaCl). The potential impacts of chlorine on the biological environment are discussed further in Section 9.10.2.2 Biological Environment.

Chlorine Modelling Outcomes

For the purposes of the impact assessment, discharge concentrations of 0.6 mg/L free chlorine and temperatures up to the maximum design level were assessed in the modelling as the worst-case scenario. The investigation of the cooling water discharges considered processes occurring at near-field and far-field scales and focused on the fate of free chlorine within the streams which included application of a conservative decay rate due to its highly volatile nature (RPS 2019b).

The 12 discharge points of the cooling water system vary by flow rate, location, orientation and port size (Table 9-36) and were assessed in a cumulative fashion in the detailed mixing and dispersion study undertaken. The cooling water discharges are located sufficiently close so that interaction is likely between a number of the cooling water plumes much of the time (Figure 9-9 and Figure 9-10).

Figure 9-9: View of cooling water discharge ports P53, P54 (inboard pair), P63 and P64 (outboard pair) that discharge rearwards on the starboard side

The collective field of effect (impact area) for chlorine contributed by all cooling water discharges occurring simultaneously was calculated at approximately 180 m from the FLNG hull for the worst-case combination of the highest potential discharge concentration (0.6 mg/L) and a no-effect threshold concentration of 3 ppb, under the 95th percentile current speed, assuming relatively calm sea conditions. Due to the short distance, this outcome can be almost entirely attributed to dispersion because the plume would have little time for decay to contribute significantly. Under the 99th percentile current (0.82 m/s), this field of effect might extend a further 30% indicating that the field of effect might extend to 250 m under more extreme and rarely occurring current speeds. The field of effect will be shorter for lower current speeds and more energetic sea conditions. Proportionally shorter fields of effect should result from discharge of free chlorine at concentrations lower than 0.6 mg/L which will be most of the time due to a continual dosage discharge target of <0.2 mg/L.

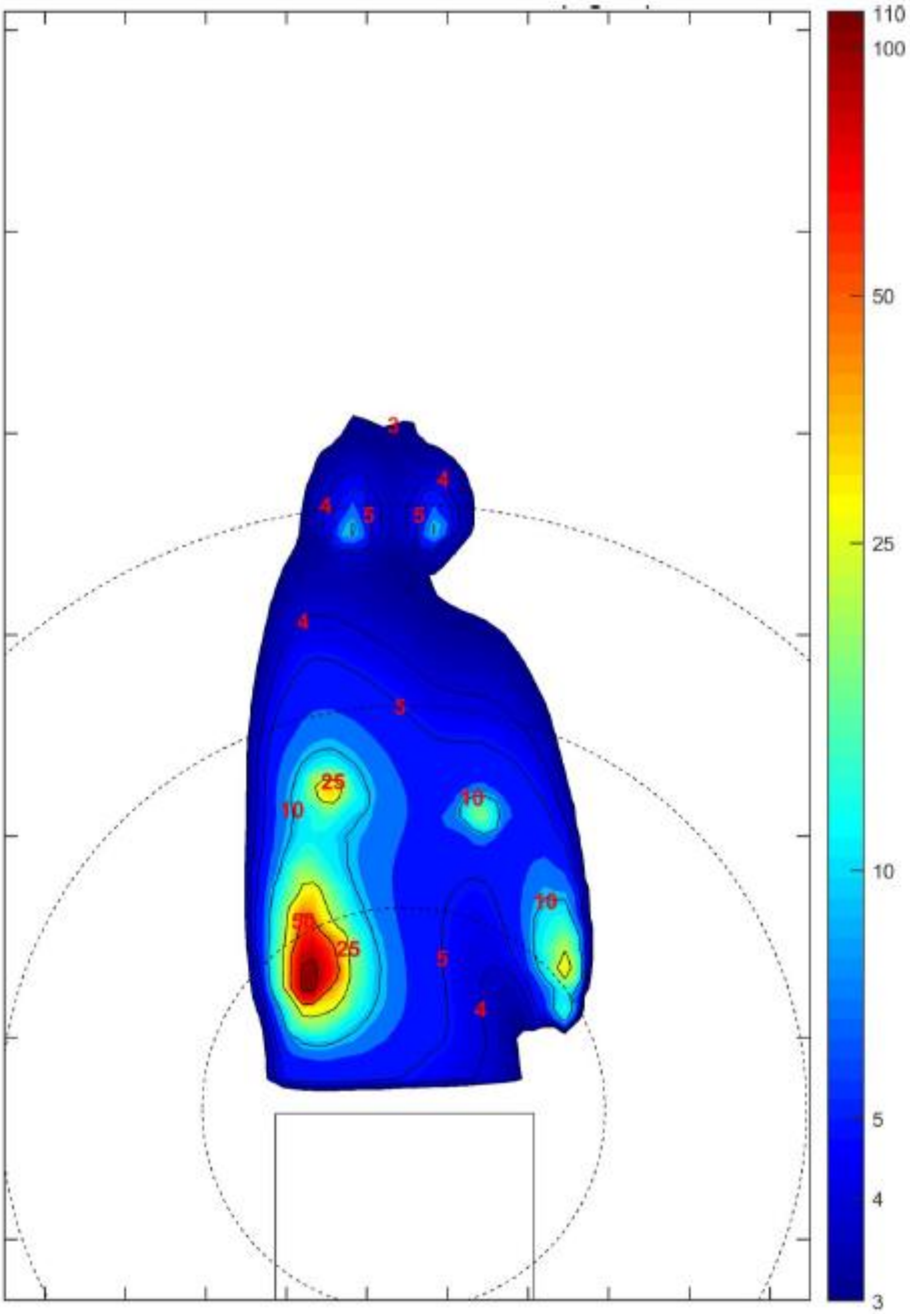

Figure 9-10: Calculation for the combined distribution of free chlorine in the far-field accounting for all water discharges under the 95th percentile current. Range rings mark 50 m increments from the stern. The field of effect is illustrated for concentrations >3 ppb free chlorine. The key shows ppb. The gap between the stern and chlorine distributions represents the near-field zone.

Temperature Modelling Outcomes

The discharge of cooling water near the ocean surface results in a change of surface temperature of the waters surrounding the FLNG facility, which may cause alteration of the physiological processes (especially enzyme-mediated processes) of exposed biota. These alterations may cause a variety of effects, ranging from behavioural response (including attraction and avoidance behaviour), to minor physiological stress, to potential mortality for prolonged exposure if temperatures are sufficiently high.

To examine the behaviour of the outfall plumes, two separate modelling studies have been undertaken to assess the behaviour of cooling water plumes from a temperature dissipation perspective. These studies are summarised below:

1. Deltares (2008) computational fluid dynamic flow simulations analysing near and far field effects for representative summer and winter conditions were conducted using the average expected discharge temperatures. In summer, the temperature of the cooling water plumes were predicted to be less than 3°C warmer than the surrounding ambient ocean within 20 m from the discharge point (Figure 9-11). During winter, the cooling water plume temperature was predicted to be within 3°C of ambient ocean water temperature within approximately 15 m from the discharge point. The zone of effect was predicted to be smaller in winter because the temperature differential between the cooling water discharge and ambient ocean is less than in summer. The potential for seawater previously heated by the FLNG cooling water discharge returning to the FLNG on the following tide and affecting temperature dilutions of subsequent cooling water discharge was also investigated. Modelling indicated that the maximum increase in background sea surface temperature in the vicinity of the FLNG facility, as a result of earlier cooling water discharges, was an additional 0.4°C. This occurs when tidal flows are low during summer. During winter, the temperature difference between the discharged cooling water and ocean is less so this temperature effect is reduced.

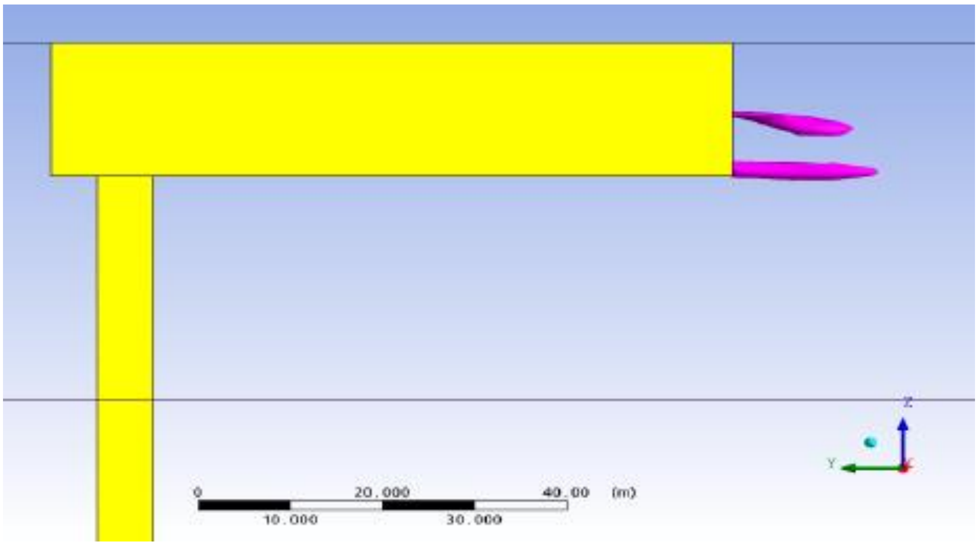

Figure 9-11: Excess temperature larger than 3°C (summer scenario, large flow velocity directed from the outlets)

2. Shell (2019) undertook sensitivity testing using the USEPA supported CORMIX model to assess the worst case scenario of the cooling water plume behaviour from the largest single port discharge rate (SW2 – 14,000m3) releasing water at the maximum piping temperature design integrity envelope upper-bound of 50°C. Although this scenario is highly unlikely, it has been included in this impact assessment to test the maximum design envelope to

gain confidence around the extent of the theoretically feasible temperature impacts as an absolute worse-case. The model was applied to determine the dilution profiles, with focus on the near-field effects, and location of excess temperature under different scenarios considering low and high tidal flow velocities, winter and summer water temperatures, and low and high wind velocities representative of the expected environmental ranges. The worst-case scenarios was predicted to occur in winter for downstream-oriented discharges under low tidal flow velocities, caused by the relatively high discharge excess temperature combined with limited strong vertical mixing due to dominant buoyancy forces. In the worst-case predicted scenario, the plume temperature was predicted to dissipate to within 3°C of ambient a distance of approximately 100 m from the discharge point (Figure 9-12). This scenario is highly unlikely though given the cooling water pipes typically discharge water a a temperature well below their maximum design integrity upper-bound. For the remaining worst-case scenarios that were modelled, the targeted temperature for the plume to within 3°C of ambient was met at distances between 4 and 39 m from the discharge point.

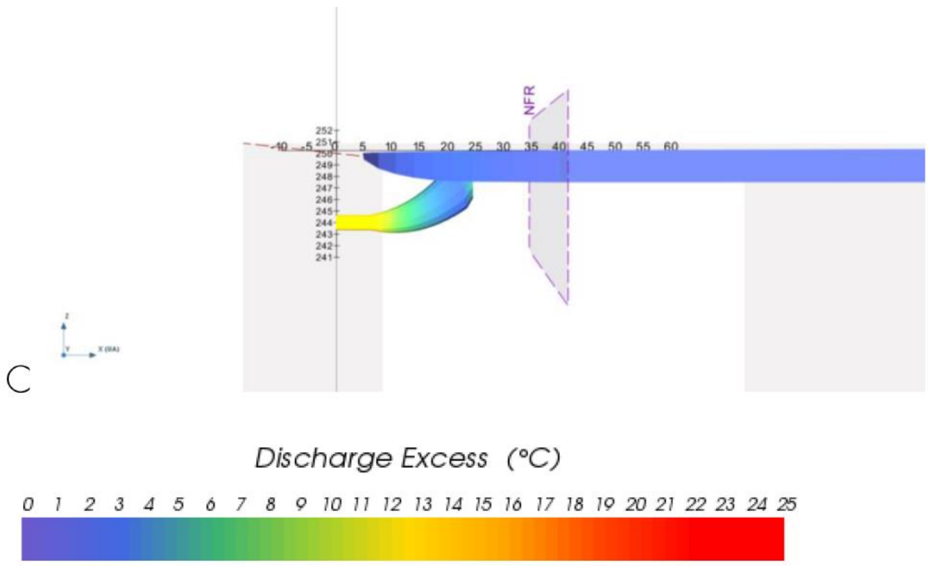

Figure 9-12: CORMIX visualisation plot for worst-case winter scenario (low wind, low flow, downstream). The Near-Field Region (NFR) is indicated in purple.

Given the high volatility state and associated high decay rate of free chlorine, rapid dilution and dispersion and temperature transference in the open offshore deepwater environment, highly localised impact area (<250m from the FLNG), and distance from the nearest values (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island ~40km away), the residual impact consequence to water quality associated with cooling water is assessed as slight (Magnitude -1, Sensitivity – L).

Desalination Brine, Boiler Blowdown and MBP Effluent

Desalination brine discharge is estimated to be up to approximately 1100 m^3/h. Being of greater density than seawater, this will sink and disperse rapidly in the deep water and open oceanic currents. The largest increase of salinity experienced would be approximately 10% in the immediate vicinity of the discharge point.

There are minor amounts of anions, cations (mostly Na+ and Cl-) and residual chemicals associated with MBP effluent resulting from the MBP regeneration process. There will also be residual chemicals additivies within the boiler blowdown operational discharges. The potential differences in pH of MBP effluent neutralisation tank and boiler blowdown water (pH range estimated at 6-12) compared to background seawater (pH approximately 8.2) are predicted to resolve very rapidly within a very localised area due to the highly dilutive open offshore deepwater environment and very good natural buffering capacity of the ocean which will quickly bring the discharge back to ambient pH (ANZECC 2000).

The residual impact consequence for water quality as a result of brine, MBP effluent and boiler blowdown discharges is assessed as slight (Magnitude -1, Sensitivity – L). No detectable impacts to marine sediment quality are predicted as a result of brine, boiler blowdown and/or MBP discharges based on the water depth, open ocean currents and low concentration/toxicity of chemical additives.

Produced Water (PW)

Water Quality

PW will be discharged from the FLNG facility and will contain a range of potential inherent and added contaminants, which is expected to include salts, hydrocarbons, metals, phenols, nutrients (e.g. ammonium) and residual production chemicals. It is anticipated that the composition of the produced water discharge will vary over time as reservoir and production characteristics change.

The PW plume is dynamic and moving constantly depending on the tides, currents, winds, and internal waves. The PW discharge is expected to be positively buoyant relative to the receiving seawater due to temperature and salinity effects. Anions are expected to predominantly comprise sodium, calcium, magnesium and potassium. Cations are expected to comprise chloride, sulphate, bromide and bicarbonate. These ions (and their associated salts) are also commonly found in seawater.

Based on operational experience to-date, potential contaminants such as Naturally Occurring Radioactive Materials (NORMs) and organic acids (e.g. acetic acid) are not expected to occur in quantities that may result in significant environmental impacts and are therefore not discussed further.

Hydrocarbons in the PW will consist of both relatively low and high molecular weight compounds. Hydrocarbon solubility generally decreases with increasing molecular weight, and aromatic hydrocarbons also tend to have increased water solubility compared to non-aromatic hydrocarbons of equivalent molecular weight (Neff et al. 2011). As such, low molecular weight aromatic hydrocarbons are typically the most available in PW. These compounds include BTEX, low-molecular weight PAHs, which include naphthalene, phenanthrene and dibenzothiophene (NPD) compounds and phenols. Low molecular weight hydrocarbons are of particular interest, as these tend to have the greatest potential for toxicity (Neff et al. 2011). Higher molecular weight compounds are largely recovered during the production and PW treatment processes onboard the FLNG facility. However, residual high molecular weight hydrocarbons may still occur in the PW stream as very fine entrained oil droplets.

BTEX compounds are the most common hydrocarbon component of PW, however are highly volatile and do not persist in the environment. Evaporation and dilution will rapidly reduce the concentration of BTEX in the receiving environment (Ekins et al. 2005; International Association of Oil and Gas Producers [IOGP] 2005; Neff et al. 2011). Other processes such as biodegradation and photodegradation are expected to further reduce BTEX concentrations in the environment (Neff et al. 2000). BTEX is known to be toxic to marine organisms and has been shown to result in developmental defects (Fucik et al. 1995) but does not significantly bioaccumulate (Neff 2002). As such, potential impacts from the decrease in water quality due to BTEX are expected be very localised around the FLNG and more so toward the end of reservoir end of life operations.

PAHs are less volatile and soluble than BTEX and have greater potential to accumulate in the marine environment (Neff et al. 2011). PAHs can be broadly divided into two types:

- Low molecular weight
- High molecular weight.

PAHs dissolved in PW are predominantly low molecular weight and, while toxic, they are not typically mutagenic nor carcinogenic (although their metabolic by-products may be) (IOGP 2005). Higher molecular weight PAHs are rarely detected in treated PW due to their low aqueous solubility. These compounds are primarily associated with dispersed oil droplets which are typically removed by the production process and produced water treatment system (Neff et al. 2011; Schmeichel 2017). PAHs are generally removed from the water column through volatilisation to the atmosphere upon reaching the sea surface, particularly the lower molecular weight fractions (Schmeichel 2017). PAHs can also degrade in the water column with half-lives ranging from less than a day to several months, with the more abundant and lower molecular weight compounds being more degradable (IOGP 2002).

A variety of metals may be present in PW in varying concentrations, some of which can cause adverse impacts in the marine environment, while others are a necessary component to maintain life with some being essential at low quantities, but potentially toxic at high levels (Khayatzadeh and Abbasi 2010). It should be noted that until breakthrough of formation water which is anticipated to be sometime during year 7-9 following startup (i.e. 2025-2027), inherent reservoir originated levels of metals within PW are expected to be low. Prior to water breakthrough, PW originates primarily from condensation of water vapour entrained within the produced gas stream which is typically free of metal contaminants given it orginates from a gaseous phase. While concentrations of trace metals in PW can be greater than those in the ambient marine environment, they are rapidly reduced through dilution and mixing processes, and other physicochemical reactions to levels that pose a nil to slight impact consequence to the receiving environment (IOGP 2005). Azetsu-Scott et al (2007) also found that despite metal concentrations being much higher in PW than those in the natural seawater, no significant correlation between toxicity and metal concentrations was observed in the study, indicating that metal concentrations alone may not be responsible for any observed toxicity.

Mercury levels in the PW to date have been measured at around 2 ppb (wt). Additionally, mercury from the nearby analogous Brewster and Plover reservoirs is elemental mercury (Hg), which is relatively unreactive, and has little tendency to dissolve in water, and readily volatises into the atmosphere (Neff 2002). Conversion of elemental mercury to methylmercury ($MeHg+$), with a potential to bioaccumulate and to be toxic, does not occur in well-oxygenated environments (Neff 2002), such as those in waters surrounding the FLNG.

A range of process chemicals will be introduced into the hydrocarbon process and may be subsequently discharged to the sea in residual amounts if they partition into the PW and are not removed via the available treatment processes. Some of the process chemicals may be at concentrations that have potential to cause impact or contribute to the toxicity of the PW, such as biocides (Neff 2002). The ecotoxicological impacts of process chemicals in PW discharges was comprehensively investigated in a study by Henderson et al. (1999). The study tested 11 commonly used process chemicals (including biocides, corrosion inhibitors and demulsifiers) for their acute toxicity to marine bacterium, both directly in aqueous preparations and following their partitioning between oil and water phases. The study results indicated that toxicity of the PW was not significantly altered by the presence of most process chemicals used in typical concentrations. A review of the study by Schmeichel (2017) notes that process chemicals make a small contribution to the overall acute toxicity profile of PW discharges and even chemicals which are classified as highly toxic may not actually present an acute toxicity risk at dosages representing normal operating conditions. As such, production chemicals in the PW discharge will not result in more than slight impact consequence to water quality.

MEG is readily biodegradable in the marine environment in aerobic and anaerobic conditions through microbial action, with studies showing degradation to < 10% of the initial concentration occurring with 1 to 21 days (Staples et al. 2001). MEG will not persist in the environment once discharged. Degradation by microbial action increases with temperature, and degradation in the warm tropical seawater at the discharge location is expected to occur rapidly. Microbial degradation will account for the fate of almost all MEG discharged. It has been shown to be practically non-toxic (based on US EPA definitions) in relation to aquatic organisms (Staples et al. 2001) and is entirely miscible in water and has low potential to combine with lipids and therefore has very low potential for bioaccumulation (Dobson 2000, Staples et al. 2001). The Oslo Paris Convention (OSPAR) Commission lists MEG as a substance considered to Pose Little Or No Risk to the environment (PLONOR).

PW Modelling Studies

Note that the standalone PW assessments presented here do not factor in any dilutive or compounding influences presented by other liquid discharge streams that may comingle with the PW following discharge, e.g cooling water. A liquid discharges cumulative impact assessment was undertaken as a separate study with the results presented primarily in Section 9.9.3. The study also did not consider the presence and influence of the ships hull on the current regime and resultant dilution/dispersion so therefore may be considered as conservative in its approach.

The APASA (2012) modelling study conducted for the PW discharge considered processes occurring at two different scales: “near-field” processes generated by the discharges and “far-field” processes generated by the ambient current field and ocean turbulence. The near-field processes are largely affected by the engineering design and parameters of the discharge, while far-field processes are affected by the local ocean dynamics and chemical processes that will be sensitive to the local setting.

Review of the toxicological literature and ANZECC (2000) water quality guidelines indicated that individual constituents within the PW discharges would require different levels of dilution to meet a defined area of effect. To be conservative for the PW streams, no decay or other degradation processes were assumed in the modelling assessment, using inert tracers to define potential fate.

- The near field modelling indicated that relatively high levels of dilution would be achieved through the jet phase and buoyant entrainment phase of the discharge (87 - 187-fold depending upon the prevailing current speed applied)

- The initial dilution calculations indicated that sufficient dilution would occur under the range of current speeds for many of the individual constituents in the near-field discharge, but not always for:
  - TPH
  - Alkylphenol
  - Chromium (VI)
  - Iron.

3-D stochastic far-field modelling of the PW discharge was then completed using the CHEMMAP model treating the discharge as a moving source incorporating the results from a long term heading analysis. Five hundred replicate short-term simulations were completed with metocean conditions randomly sampled from the 39-year hind cast data set. The far-field study also assessed the potential for recirculation of the plume back to the discharge location, in which case the near-field concentrations might be increased beyond those indicated in the near-field modelling. The results are summarised below:

- At 200 m from the source, exceedence of the defined thresholds was not predicted for any of the specified consituents except for TPH; and
- TPH discharged at 30mg/L requires a minimum of 4,286 dilutions to meet the defined threshold of 0.007mg/L, this was predicted to occur at a maximum of 1,030m from the discharge point during all modelled scenarios as shown in Table 9-41.

Table 9-41: Maximum distances forecast for far field PW dilution levels

Dilution level	Maximum distance to reach dilution level (m)
×5000	1030
×3000	746
×1000	355

The defined threshold for TPH is a highly conservative and chronic value taken from ANZECC 2000 (As derived from Tsvetnenko [1998]). Given the conservative thresholds established for TPH and the conservatism built into the model, it is reasonable to assume that suitable dilutions would occur >95% of the time within 1 km from the FLNG to meet the 95% species protection level. This is supported by the modelling results which predicts 5000 dilutions at a maximum distance of 1030m from the source (refer Table 9-41).

The proposed mixing zone extent is supported by an additional model study undertaken by RPS (2019a) which assessed the PW plume behaviour if PW is dosed with 20% MEG to assess and density effects on the number of dilutions required to meet the defined threshold of 7 ppb. In this study, the worst-case linear distance calculated for the end of the effect zone (4300 dilutions required) from any location on the hull was calculated at 667 m (Figure 9-13) indicating that applying a 1 km mixing zone for the impact assessment of PW is sufficiently conservative.

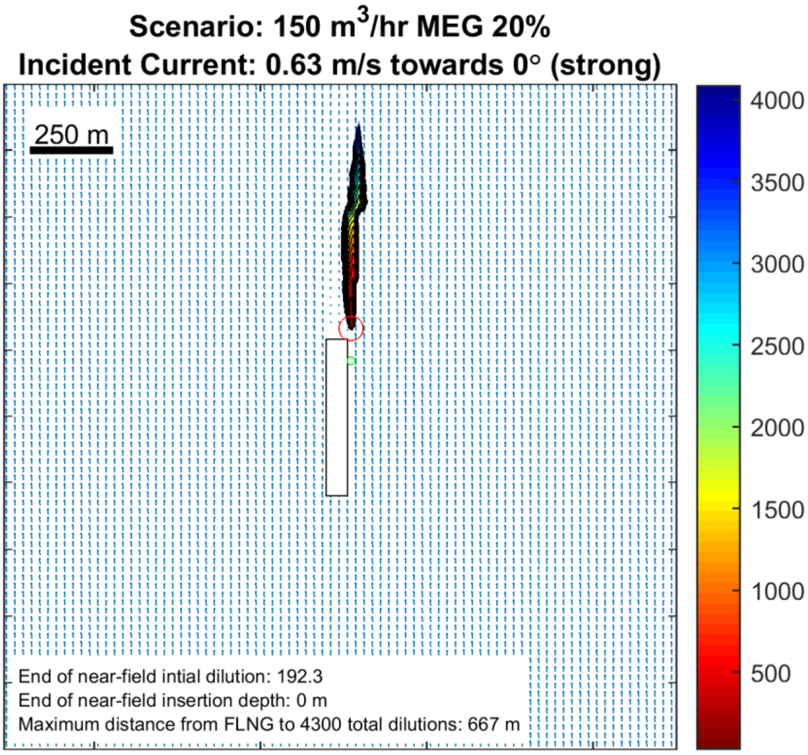

Figure 9-13: Dilution fields calculated for discharge into the wake zone of the FLNG (strong current, 20% MEG)

For the short duration and infrequent periods where discharged TPH levels may be up to 100mg/L (well cleanup) as described in Section 9.10.1.5 Produced Water (PW), extrapolating the information from Table 9-41, it is reasonable to expect at least 15,000 dilutions will occur within 2000 m of the source. In support of this prediction, literature reviews undertaken showed that at 500-1000 m of the discharge points, dilution rates of 1,000 – 100,000 are typical (IOGP 2005; Neff et al., 2011). Therefore, beyond 2000m, there are predicted to be no exceedances of the adopted 7ppb TPH threshold for these short term and once-off events per well.

Given the receiving environment (water column) is the same out to 2000m from the FLNG and well represented within the region, short-term and infrequent elevations within this larger footprint are not significant in a local or regional context and are not predicted to alter the residual risk ranking.

<u>Sediment Quality</u>

The PW discharge will contain a range of potential residual constituents as discussed in the water quality section above. There are several processes by which these could become incorporated into the sediment if conditions were suitably conducive, including:

1. Sedimentation of inherent solids in the PW.
    - The production process onboard the FLNG will remove most inherent solids from the produced water prior to discharge. Therefore, the mass of solids discharged in the PW is expected to be very low. The remaining solids will be very fine in size, and hence will have low settling velocities. Given the water depth at the discharge location, the predicted behaviour of the plume, the surface discharge point, and the low settling velocities, inherent solids will disperse widely and will not result in

impacts to sediment quality surrounding the discharge location within the currency period of this EP.

2. Dissolved contaminants forming precipitates, which settle to the seabed.
    - Dissolved constituents (particularly metals) in the PW may form precipitates once released into the environment due to changes in pH and availability of reactants (e.g. oxygen, sulfide etc.). Metals commonly encountered at elevated levels in PW that may form precipitates include barium, iron and manganese (Neff et al. 2011). Solids formed by precipitation are initially very fine and will have low settling velocities. As with inherent solids released within the PW, formed precipitates are unlikely to be deposited near the discharge location and will disperse widely. Therefore precipitates will not result in impacts to sediment quality at or surrounding the discharge location during the currency period of this EP.
3. Adsorption of contaminants onto natural suspended solids, which then settle to the seabed.
    - Some of the potential constituents in the PW, such as metals and hydrocarbons, may also become adsorbed onto the surface of suspended solids present in the receiving environment. Water quality studies in the project area have shown that natural suspended sediment levels are low (Shell 2009). This is consistent with the low observed rates of natural deposition in the region as per Glenn (2004) which states that sediments locally derived from the water column are generally very fine (i.e. silt and clay sized particles). The low natural suspended sediment load indicates the potential for adsorption of potential contaminants is limited. Due to the small particle size, the potential for adsorbed contaminants to be deposited at and concentrated around the discharge location is low; particles with adsorbed contaminants are expected to be widely dispersed, resulting in no impact to sediment quality in the surrounding area.

As particles pass through the water column they will be subject to natural dispersion through oceanographic processes. In the deep waters around the FLNG (>230 m), Stokes' Law indicates a settlement time of approximately >600 days for a 70 µm particle. Therefore, all anticipated particles which will range up to a maximum size of <70 µm, will not settle locally around the FLNG facility and are likely to be dispersed throughout the broader Browse Basin. Even once settled, if at all, finer fraction particles are likely to be transported further afield via resuspension, resulting in secondary further dispersion until they assimilate into the resident sediments, if at all.

Each of the mechanisms discussed above by which contaminants in the PW may settle and be incorporated into sediments is considered to result in no environmental damage or effects on sediment quality around the FLNG facility. This is consistent with monitoring results for other offshore facilities, which generally show that natural dispersion processes appear to control the concentrations of potential contaminants from PW in sediments to slightly above background concentrations and below levels known to cause deleterious effects (Neff et al. 2011; Barnes et al. 2019). The discharge volumes of PW are expected to be relatively low for the majority of the production period, before increasing as the reservoir becomes depleted. Therefore, the period with the credible potential for sediment quality impact is concentrated at the end of field life for the Prelude reservoir which is beyond the spatial scale of this EP's currency period.

<u>Summary</u>

Given the rapid dilution and dispersion in the open offshore deepwater environment, highly localised impact area, and distance from the nearest high value sensitive receptor (Continental Slope Demersal Fish Communities ~ 14 km and Browse Island

~40km away), the residual impact consequence to water quality associated with PW is assessed as slight (Magnitude -1, Sensitivity – L).

Given the water depth (>230 m), low inherent and ambient solids, low predicted rates of precipitation, small particle size and highly dispersive environment, the residual impact consequence to sediments as a result of PW discharge is expected to be no impact (Magnitude 0, Sensitivity – L). This impact ranking will be reassessed with each mandatory re-submission of this EP to ensure currency.

Use and Discharge of Ad-Hoc Chemicals

The infrequent release of minor quantities of chemicals and production fluids due to planned ad hoc discharge activities may result in a localised and temporary reduction in water quality around the discharge which has the potential to impact on marine fauna (discussed further in Section 9.10.2.2 Biological Environment). Discharge of small volumes of these fluids are predicted to disperse and dilute rapidly with the spatial extent of any impacts likely to be limited to the water column, and very localised around the discharge point. Therefore, the residual impact consequence is assessed as slight (Magnitude -1, Sensitivity – L).

9.10.2.2 Biological Environment

Drainage (Slops) and Bilge Effluent

These effluents have the potential to adversely affect water quality which may impact some biological receptors in the immediate area through acute or chronic toxicity. The potential biological impacts of these discharges are addressed further in the broader PW assessment within Section 9.10.2.2 Biological Environment and the liquid discharges cumulative impact assessment in Section 9.9.3. This is given the similarities in the cause and effect pathways and that impacts are not anticipated to be greater than those presented in the PW assessment from these smaller volume and infrequent discharge streams.

Overall, the residual impact of the discharge of treated drainage (slops) and bilge effluent to the biological environment with the stated controls in place is considered to be of slight impact consequence (Magnitude – 1, Sensitivity – L).

Food Waste, Sewage and Greywater

Nutrients in sewage greywater and food waste, such as phosphorus and nitrogen can contribute to eutrophication of receiving waters. However, this is only likely in still, calm, inland waters, where it can cause algal blooms, which in turn degrades aquatic habitats by reducing light levels and producing certain toxins, some of which are harmful to marine life and humans. The low level of nutrient outputs as shown in Table 9-37 are not expected to result in levels or conditions that could result in excessive algal, phytoplankton or cyanobacterial growth or associated depletion reduction in oxygen levels. Sewage and greywater can also contain hazardous pathogens (including faecal coliform bacteria), intestinal parasites and viral agents that, if released, may cause contamination to the food chain and/or other marine users. This is further addressed in Section 9.10.2.3 Socio-Economic Environment, under the socio-economic environment impact assessment and will not result in environmental damage or effects.

The overboard discharge of sewage and food wastes creates a localised and temporary increase in particulates on or near the surface waters. This may in turn act as a food source for scavenging marine fauna and seabirds, whose numbers may temporarily increase as a result. The ingestion of small (macerated or reduced to <25mm) particle sizes within the effluent is not anticipated to have an adverse physical or toxic impact on resident and transient marine fauna, including listed threatened and migratory species, e.g. cetaceans or whale sharks.

Open marine waters are typically influenced by regional wind and large scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage, greywater and food waste discharges will occur. Therefore, nutrients from these discharges will not accumulate or lead to eutrophication due to the highly dispersive environment. As such, the receptors with the greatest potential to be impacted are those in the immediate vicinity of the discharge. Effects on environmental receptors along the food chain, namely, fish, reptiles, birds and cetaceans are therefore not expected beyond the immediate vicinity of the discharges.

Although the Timor Sea is characterised as a low nutrient environment (Brewer et al, 2007), natural seasonal upwelling can result in localised and sporadic high phytoplankton productivity along the Sahul Shelf including immediately offshore of the shelf. The estimated daily loading from sewage, grey water and food waste (Approximately 37 kg/day of TN and 7 kg/day of TP) is considered inconsequential in comparison to the daily turnover of nutrients in the area.

The rapid consumption of macerated food and sewage waste by scavenging fauna, combined with physical and microbial breakdown, ensures that any impacts of sewage, greywater and food waste discharges are short-lived, localised and negligible. There are no nearby sensitive or high environmental value habitats or biological communities that are at risk from temporary increases in nutrient levels, particulates and/or increased numbers of scavenging fauna. The volume of these discharges is small relative to daily nutrient turnover in the given area of ocean and the associated assimilative capacity of the receiving offshore environment. Therefore, the environmental impact associated with the discharge of sewage, greywater and food waste is considered to be slight (Magnitude -1, Sensitivity – L).

Cooling Water

The effect of chlorine on marine organisms is well known, given its widespread use as a biocide (Abarnou and Miossec 1992). Sublethal effects of chlorine on marine biota include growth reduction in some invertebrate larvae (Best et al. 1981), alteration of membrane permeability, modification of blood composition, and reduction in primary producer productivity (Best et al. 1981; Abarnou and Miossec 1992). Concentrations of free chlorine in seawater that can trigger lethal and sub-lethal response have been shown to vary among different species and are also dependant on water quality, being affected by:

- pH
- concentrations of ammonia
- negatively charged inorganic compounds
- Various organic compounds.

Guidelines for the maximum discharge concentrations in marine waters have been set by a number of authorities around the world, which differ widely in both the levels that are set and the reactants that are considered. ANZECC (2018) does not specify any set threshold for chlorine or chlorine products in marine water for Australia, citing a lack of evidence required to set a meaningful limit, but suggests using 3ppb as a Low Reliability Value (LRV) in association with other appropriate lines of evidence. Although this 95% species protection level is relatively close to the acute toxicity value for the most sensitive of the tested species, this was considered sufficiently protective, due to its short residence time, the narrow difference between acute and chronic toxicity and the lesser sensitivity of data for other tested species (ANZECC 2018).

The intent of LRVs are to provide guidance in the absence of any higher reliability guidelines being available and are derived by applying larger application (safety) factors to the toxicological data to account for the greater uncertainty associated with the limited database (DWER 2017). The ANZECC LRV for chlorine is therefore considered as conservative and may not necessarily reflect concentrations above which toxic effects would occur. ANZECC & ARMCANZ (2000) cautions that LRVs should not be used as default guideline trigger values, but further states that ‘it is reasonable to use them in the risk-based decision scheme to determine if conditions at the site increase or decrease potential risk’. In other words, it is reasonable to assume that if ambient concentrations fall below the LRV then there is a low potential of ecological impact. However if concentrations are above the LRV, it does not necessarily mean an impact is a given, rather that further investigation and adaptive management may be required.

Assessment of water quality guidelines for chlorine from a number of other jurisdictions have also been provided in Table 9-42 to demonstrate that the proposed trigger level of 3ppb at the edge of the defined mixing zone is consistent and comparable.

Table 9-42: Guidelines for chlorine concentration in water

Authority	Guideline, Limit, or Trigger (ppb equivalent)	Comments
DWER (2017) for Cockburn Sound, Western Australia	3	Taken directly from the ANZECC (2000) LRV.
British Colombia (Water Protection & Sustainability Branch [2018]) (Chronic)	3	Based on average continuous exposure.
Canadian Council of Ministers of the Environment (CCME) (2008)	2	This is the freshwater guideline for this jurisdiction.
USEPA (Chronic) (2019)	7.5	Derived from 24 marine species in 21 genera. The sensitivity results were very similar to that observed in freshwater species and fish and invertebrate species had similar sensitivities.
USEPA (Acute) (2019)	13	

Toxicity assessments undertaken for specific marine species indicate that a 3ppb trigger level affords sufficient protection by a factor of 6-62 times that of the available chronic NOECs (ANZECC 2018):

- Marine fish: Two species, 48 to 96-hour LC50 128 to 250 µg/L (2 to 8 hours/day intermittent to continuous dosing). Chronic NOEC (7-day growth), Menidia beryllina, 87 to 186 µg/L.
- Marine crustacean: one species, *Mysidiopsis bahia*, 96-hour LC_{50}, 73 to 268 µg/L (2 to 8 hours/day intermittent to continuous dosing). Chronic NOEC (7-day reproduction), M. bahia, 20-87 µg/L.
- The 24-hour LC_{50} for the marine prawn, Penaeus plebejus, was 180 µg/L.

An additional assessment for chlorine was also undertaken during the development of this EP to develop a Species Sensitivty Distribution (SSD) curve and associated levels of species protection utilising the CSIRO hosted Burrlioz statistical analysis software in accordance with Warne et al. (2018) and CSIRO (2019). The data utilised for the assessment were the LC_{50} values listed above for marine species in ANZECC (2018) as well as appropriate data for marine species obtained from the USEPA Ecotox database (https://cfpub.epa.gov/ecotox//search.cfm) accessed on 29 July 2019 where this data passed the screening tests as described in Warne et al. (2018). Data filters were applied to select the appropriate values to assess through the Burrlioz software package which included:

- Retention of data for marine species only
- Removal of all data derived earlier than 1980
- Retention of available data for EC/IC/LC_{50} tests only
- Utilisation of the geometric mean where data were provided for the same species and ecotox test methodology/duration
- Selection of the lowest value per species
- Application of an Acute to Chronic Ratio (ACR) of 10 as per the default value recommended in Warne et al. (2018).

The assessment described above yielded the following results:

- 95% Species Protection Level = 13 ppb
- 99% Species Protection Level = 11 ppb.

Given these values were derived from relatively limited data sets in terms of sample size, they are not being suggested to replace the ANZECC LRV of 3 ppb as the trigger level (LRV) but rather are provided as an additional line of evidence to demonstrate that managing to this concentration is a conservative approach that should afford sufficient ecologoical and species protection.

As a benchmark for this impact assessment, cooling water discharge predictions were compared to the IFC (2015) guidelines for water temperature. The guidelines suggests discharges should not result in a temperature differential of greater than 3°C relative to the ambient temperature at the edge of a defined mixing zone which suggests a default distance of 100m. The modelling studies undertaken have indicated that the IFC guidelines will be met under all seasonal conditions within this defined mixing zone which is appropriate due to the lack of sensitive receptors within such a small localised area. In addition, given the cooling water dischrges are continual, free swimming organisms are expected to perform avoidance behaviors towards plumes outside of their tolerable ranges. Therefore from a temperature only perspective, cooling water is assessed as having no residual impact consequence (Magnitude 0, Sensitivity – L).

In terms of vertical distribution of the cooling water plumes in the far-field, given the significant water depth and positive buoyancy of the plumes, dilution is predicted to be such that there will no effects on sediments and/or marine biota associated with the seafloor such as demersal fish or invertebrate assemblages.

Overall, given the highly dispersive nature of the receiving environment, positive buoyancy of the plumes, the rapid dilution following discharge, that free chlorine does not persist long in the marine environment and the lack of resident sensitive and/or high value receptors, cooling water is not expected to result in credible impacts to higher order organisms such threatened or migratory species that may intersect the plumes and at worst is assessed as presenting a residual impact consequence of slight to pelagic communities (Magnitude -1, Sensitivity – L). Anecdotal observational evidence from the FLNG indicates there have been no obvious impacts or behavioural changes to pelagic communities to-date, with marine fauna such as fish, present in the immediate vicinity of the cooling water discharges with no apparent stress or behavioural related responses.

Desalination Brine, Boiler Blowdown and MBP Effluent

The potential impacts of desalination brine have been subject to a considerable amount of study due to the large number of high-volume desalination plants in operation within Australia. As a result, the potential impacts are well known. Marine organisms exist in osmotic balance with their ocean and exposure to a rapid change in salinity has the potential to result in the dehydration of cells, decreasing turgidity with potentially lethal consequences. Most marine species are able to tolerate short-term fluctuations in the order of 20% to 30% (Walker and McComb 1990), and it is expected that all resident and transient species would tolerate any exposure to the slightly increased (approximately 10% above background) salinity plume caused by the discharged FLNG brine prior to dilution to ambient levels. Therefore the impact of incremental salinity increases within the discharge stream is not considered further as there will be no related environmental effects or damage.

The chemicals used in all three systems typically have low inherent toxicity, low residual discharge concentrations and/or the active ingredients are consumed through the process for which they are utilised. Based on the available chemical ecotox reports and associated conservative estimated end-of-pipe discharge concentrations, it was estimated that the required number of dilutions for each discharge stream to reach its Predicted No Effect Concentration (PNEC), as calculated using the CHARM methodology (CIN 2017), were approximately:

- Desalination Brine: 1.25 – 240 dilutions required
- Boiler Blowdown: 400 – 839 diltions required
- MBP Effluent – N/A PNEC could not be calculated due to inability to undertake meaningful ecotox tests on the associated products given the need to neutralise samples to undertake such tests. However, both HCl and NaOH are ranked E under the OCNS grouping system which represents the least hazard potential and therefore any impacts are considered negligible due to the rapid buffering capacity of the open ocean.

The number of dilutions provided above is considered highly conservative as these additives are typically ‘consumed’ in the process, with much lower or no residual levels remaining upon consumption or discharge (HydroBiology 2006). As discussed further in Section 9.10.3.4 Desalination Brine, MBP Effluent and Boiler Blowdown Discharges, the required level of dilution for all three streams is predicted to be achieved within 80m of the FLNG facility under the 95th percentile current regime.

Based on the discussion above, the residual impact as a result of the discharge of desalination brine, MBP effluent and boiler blowdown are considered to be of slight impact consequence (Magnitude -1, Sensitivity – L).

Produced Formation Water (PW)

<u>Benthic Communities</u>

Given the water depth that Prelude is moored in, and the analysis conducted on the discharge streams, there will be no direct interation of the plume with the benthic environment. The only potential impact pathway is likely to be via inherent solids, precipitates or adsorbed particles settling onto the seabed over time. This may include metallic mercury, chlorides or other unknown contaminants if they have the potential to form due to plume interactions or other processes. Due to the considerable water depth highly dispersive currents, small particulates, low particle concentrations and likely resuspension and further dispersion of the finer fractions, the time for particulates to settle will be such that any settlement will likely be spread over a widespread area of the seabed (10s-100s of km). This will take a considerable amount of time (10s of years) to accumulate into detectable limits above background, if at all, and levels attribtable to planned discharges will not reach levels that are known to cause deleterous effects on the benthos.

Therefore the residual impact consequence of PW discharge on benthic communities for this revision of the EP is assessed as no impact (Magnitude 0, Sensitivity – L). This impact assessment and resultant ranking will be revisited upon future mandatory revisions of the EP.

Pelagic Communities

The decrease in water quality from potential contaminants in the treated PW discharge stream may result in localised acute impacts to plankton. Research indicates that zooplankton exposed to low molecular weight hydrocarbons can exhibit acute toxic effects (Almeda et al. 2013; Jiang et al. 2010) and developmental defects in fish (Fucik et al. 1995). In particular, PAHs are of concern due to their solubility, toxicity and relative persistence compared to BTEX. The concentrations and durations of exposure required to induce such effects on plankton populations will be be short-lived and highly localised due to the rapid dilution and decay of PW constituents, well mixed open offshore ocean environment and transient nature of planktonic communities.

Pelagic fish attracted to and organisms attached to the FLNG hull structure may be exposed to low but potentially toxic concentrations of contaminants within the PW mixing zone. However, some free swimming species are expected to move away from the area if they are able to detect nuisance concentrations of PW constituents, which will be localised to the vicinity of the release location.

Fish can also bioaccumulate heavy metals through food and via water, but uptake by individuals and by different species of fish is dependent on many factors including the metal's form (inorganic versus organic), water chemistry and behavioural traits (feeding, range) of the fish species in the receiving environment. Atchison et al. (1987) reviewed acute and chronic toxicity of metals relating to a variety of fish species and found mercury (inorganic and methyl) and copper to be the most toxic. Some heavy metals, such as mercury are persistent and can bioaccumulate (Nigro and Leonzio 1996), however some fish species may be able to metabolise metals potentially further reducing the already slight impact profile (Hodson 1988).

Some fish are able to metabolise and excrete hydrocarbons, potentially reducing physiological effects to fish exposed to PW hydrocarbons (Bakke et al. 2013). For example King et al (King et al. 2005) reported hydrocarbon-degrading bacteria in the liver and bile of fish collected from their study on the North West Shelf (NWS). Bakke et al. (2013), who reviewed individual, population and ecosystem level biological responses to PW further concluded that the spatial scale of impact from PW discharge was insufficient to impact populations of marine organisms.

Initial WET testing was undertaken on treated PW samples collected on 29 April and 6 May 2019. Although it should be acknowledged that not all listed process chemicals were being dosed at this time, regardless the results still provide an indication of the effluent toxicity presented by the PW originating from the reservoir. This provides a high level of confidence around the predicted impacts associated with PW discharges. The following toxicity tests were undertaken for each of the sampling and analysis events:

- 72-hr marine algal growt
- 48-hr oyster larval development
- 1-hr sea urchin fertilisation success
- 72-hr sea urchin larval development
- 48-hr acute copepod survival
- 96-hr acute amphipod survival.

The methods described in Warne et al. (2018) and CSIRO (2019) were applied to the relevant data to generate Species Sensitivity Distribution (SSD) curves (Figure 9-14) and associated levels of species protection utilising the CSIRO hosted Burrlioz statistical analysis software.

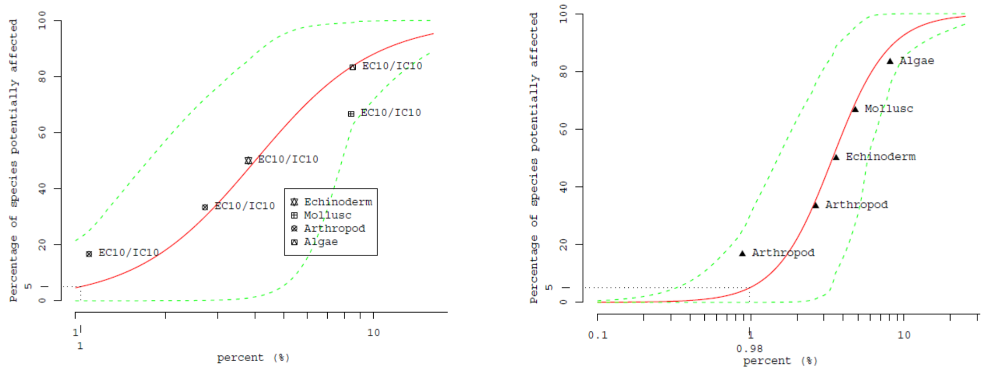

Figure 9-14: SSD curves developed from the PW WET testing results from samples collected from the Prelude FLNG on 29 April (left) and 6 May 2019 (right)

This calculated that 95% species protection was provided by 1% and 0.98% PW for the respective sampling events, i.e. 100-102 dilutions were required for each of the samples to protect 95% of species. As depicted in Figure 9-15 taken from APASA (2012), this required level of dilution is expected to be achieved in the near-field or very rapidly within the far-field but within 100m of the discharge point if utilising the predicted 95th percentile dilution predictions.

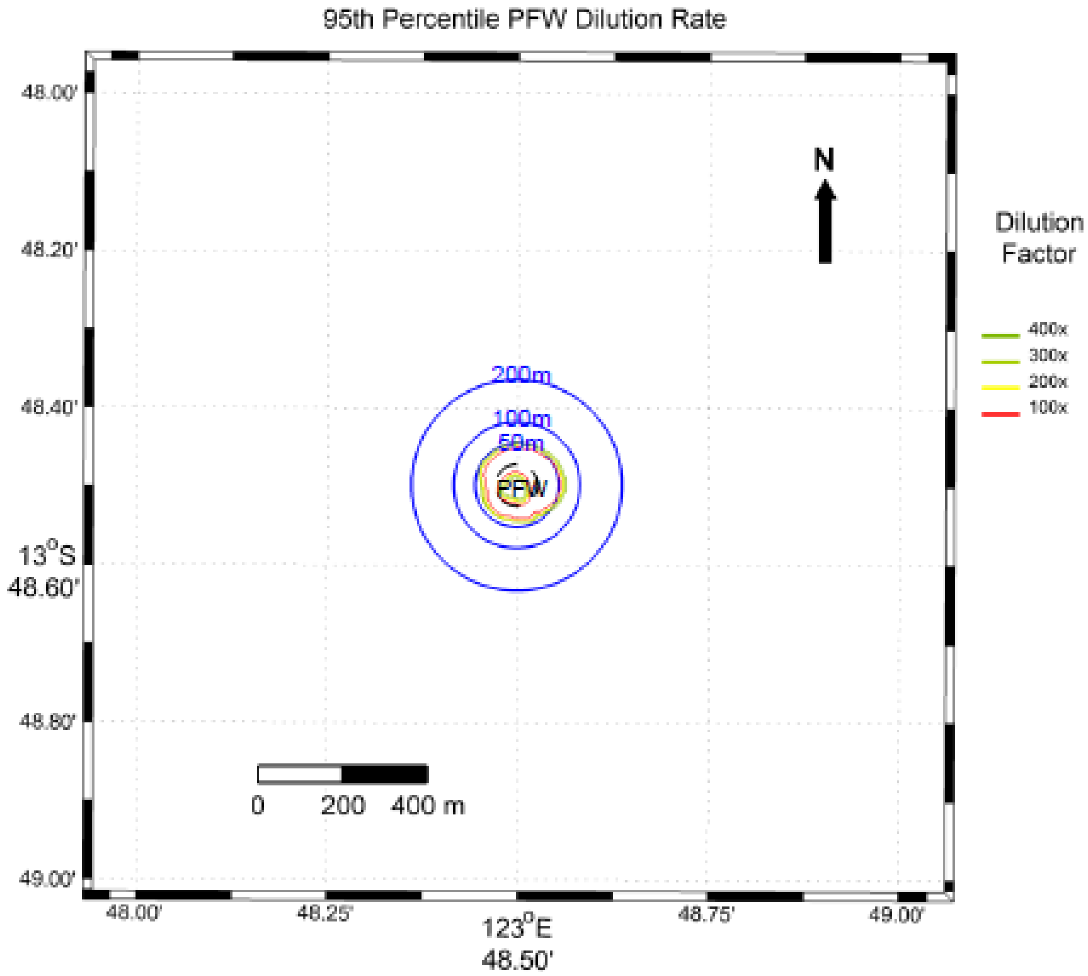

Figure 9-15: Predicted 95th percentile PW dilution (i.e. dilution is less than this 5% of the time) from APASA (2012)

A literature review undertaken showed that at 500-1000m of the discharge points, dilution rates of 1000 – 100 000 are typical (Neff et al., 2011). This further provides a high level of confidence that the defined impact threshold (95% species protection) for PW will be maintined within 1 km of the FLNG greater than 95% of the time. This recognises that there will be a potential gradient of impact with receptors within this mixing zone subject to higher concentrations of contaminants closer to the discharge release point. However impacts to the identified receptors with be managed to ALARP and acceptable levels through implementation of the identified controls and associated EPSs.

In summary, exposure of pelagic communities to PW, could result in localised environmental effects on individual organisms, but with no ecosystem function changes or chronic level impacts to populations. The impact on pelagic communities is therefore assessed to be Slight (Magnitude -1, Sensitivity – L).

Threatened and Migratory Species

As the plume is dynamic and moving constantly depending on the tides, currents, winds and internal waves, transient biota such as migrating whales or whale sharks, are unlikely to be exposed to elevated contaminant concentrations for extended durations.

Most threatened and migratory fauna species with the potential to interact with the PW plume are air breathing vertebrates, whom are typically not affected as their skin is relatively impermeable and they breathe air. Indirect impacts, such as altered prey abundance or ingestion of bioaccumulated toxic compounds is considered to be of no effect given the localised area predicted to be impacted by PW, the typically temporary or transitory presence of threatened and migratory fauna species, and the nature and scale of impacts to the marine ecosystem within the PW discharge plume (i.e. slight impacts to food sources such as plankton and pelagic fish species).

Given the absence of impacts to higher order marine fauna, limited spatial extent of water quality impacts (within 1 km from the FLNG), the infrequent and short interaction duration (i.e. minutes at a time) with the PW plume, and that only a very small proportion of the migrating/foraging population would intersect the discharge plume if at all, there are no predicted residual impacts to these receptors (Magnitude 0, Sensitivity – M).

Use and Discharge of Chemicals in Ad-Hoc Discharges

Chemicals used on the facility could cause impacts for specific biota when released to the environment depending on the nature and degree of exposure received by a particular receptor. Given the short-term durations and low frequencies of the discharges described in this section, any potential effects are likely limited in duration to a matter of minutes after the release, and confined to a small area in the water column, and therefore only to a low number of individuals that may intersect the discharge plumes prior to sufficient dilution. No adverse environmental effects are expected at a community or habitat level for any species. Many chemicals selected for use subsea (e.g. control valve fluid) or on the facility are water-soluble. As such, emphasis is placed on minimising/optimising volumes stored, used and discharged wherever practicable given the inability to recover these substances once released.

Chemicals present within these discharge streams are predicted to have slight residual impact consequence at worst (Magnitude – 1, Sensitivity – L) given the typically low toxicity of chemicals selcted through the Shell Chemical Management Process (Section 10.1.10), distance to sensitive habitats, lack of sensitive receptors and high inherent rates of dilution and dispersion.

9.10.2.3 Socio-Economic Environment

Impacts on social receptors such as recreational users and commercial operators of fishing, aquaculture, diving and boating operations, are not predicted nor are credible due to exclusions in place via the gazetted PSZ, the localised nature of the discharges and the rapid dispersion and dilution in open offshore waters.

There are no known sensitive receptors to human pathogens in the vicinity of the liquid discharges location. It is expected that any discharged pathogens will be susceptible to rapid mortality following exposure to natural levels of UV radiation, oxygen, increased salinity and natural predation resulting in their reduction and ultimate destruction (ANZECC & ARMCANZ 1997). Regardless, transference of human pathogens into marine fauna resulting in adverse impacts to the organism itself, fishermen or consumers is not anticipated to occur and/or is not considered a feasible cause and effect pathway due to the inherent biologial and physiological differences in the host species' and is therefore considered to present a non-credible impact. There are no identified recreational uses within the vicinity and therefore any impacts associated with human primary/secondary contact and the presence of 'nuisance' organisms is considered as non-credible.

9.9.3 Cumulative Impact Assessment

The Prelude FLNG routine planned liquid discharge types and rates are typical of most manned offshore facilities and the specific characteristics of each are summarised in Table 9-36. Many design considerations were made in the location of individual discharge ports and intakes, including potential for interaction and recirculation. However, as the FLNG facility sits in an open offshore environment where current conditions may be highly variable and omni-directional, there is a potential for interaction between some different discharge plume types.

Interactions of the various liquid discharge plumes may be possible under the following circumstances:

- The discharges are located in sufficient proximity so that the dynamic plumes may overlap (Refer to Figure 9-8);
- Certain or changing ambient current directions bring the plumes of the same or other discharges into the discharge path of a plume; and/or
- Severe conditions create substantial turbulence that allows interaction of plumes that are normally at different depths.

As discussed earlier in Section 9.9.2, detailed impact assessments of the individual discharge stream types have been undertaken as standalone reviews. However, as the FLNG includes multiple, proximal located discharges that may comingle following release (Figure 9-8), a study of the potential for these plumes to interact, and the likely level of common constituent intersection and associated constituent compounding was undertaken (RPS 2019b) to inform a cumulative impact assessment. This study calculated the defined fields of effect (impact area) of wastewater discharges from the Prelude FLNG, taking account of any co-mingling or cross-contamination potential. Such fields of effect were calculated as the maximum distance from the FLNG where concentrations might exceed Predicted No-Effect Concentrations (PNECs) for each constituent of concern calculated using available ecotoxicity data and applying the CIN (2017) methodology.

Liquid discharges undergo dilution through multiple processes:

- Turbulence generated by the momentum of the water passing through a restricted port
- Turbulence generated by the discharge jet penetrating the receiving water due to viscous resistance
- Dispersion occurring as the plume rises or sinks due to relative buoyancy
- Dispersion due to advection and turbulence present in the water column.

The first three processes are dominated by the characteristics of the discharge, including the flow rate, port size, orientation and water density, relative to the receiving water, and is complete within relatively short time and space scales. Hence, are commonly referred to as “near-field” processes. The fourth process will occur later and will be dependent upon the levels of mixing energy that are set up by ambient current and wave action around the discharge location. This fourth process occurs over longer time and space scales and is commonly referred to as the “far-field” process. PW, Treated Drainage and Bilge (Slops) Discharges Treated drainage (slops) and bilge waste flows are expected to be relatively low volume and frequency, and at a much lower order than PW and cooling water in particular. The PW, drainage (slops) and bilge waste flows are grouped in this cumulative assessment given that all three discharge streams are expected to contain oil in water (TPH).

Allowing for the dilutive influence of other discharge plumes (e.g. CW) and cases where the PW stream angles away from the hull when the discharge location is in the lee of the hull (when the current is towards the port bow), the adopted threshold is predicted to be achieved before it departs the lee of the FLNG under the 95th percentile current regime.

Given the PW discharge is located some distance (>400 m) from the other two hydrocarbon influenced discharge ports (slops and bilge), any influence of PW stream on the physical or chemical behaviour of these other discharge plumes is predicted to have no effect. By this point the PW stream is predicted to have diluted in the order of thousands of times already which will result in all defined constituent PNECs being achieved prior to any plume intersection (Refer to Figure 9-16 and Figure 9-17).

Any interaction with or flow past the main cooling water discharges will result in entrainment within the cooling water plume and accelerated dilution due to increased energy and turbulence. In the case of interaction with SW2 in particular, where the flow rate is significant, the PW plume would be completely disrupted and entrained into the cooling water plume, dramatically increasing the effective dilution of the PW plume as it undergoes a secondary nearfield phase. Contaminants already at very low concentration are then further diluted. As indicated in Figure 9-16 and Figure 9-17, there are no significant TPH compounding effects predicted between the PW and bilge/drains(slops).

As shown in Figure 9-17, the treated bilge and drainage (slops) discharge plumes are anticipated to comingle but the resultant plume TPH concentration is predicted to be diluted to within the defined 7 ppb PNEC within 150 m of the FLNG under the 95th percentile current regime. Allowing for the 99th percentile current, the field of effect could extend to 200m from the FLNG facility.

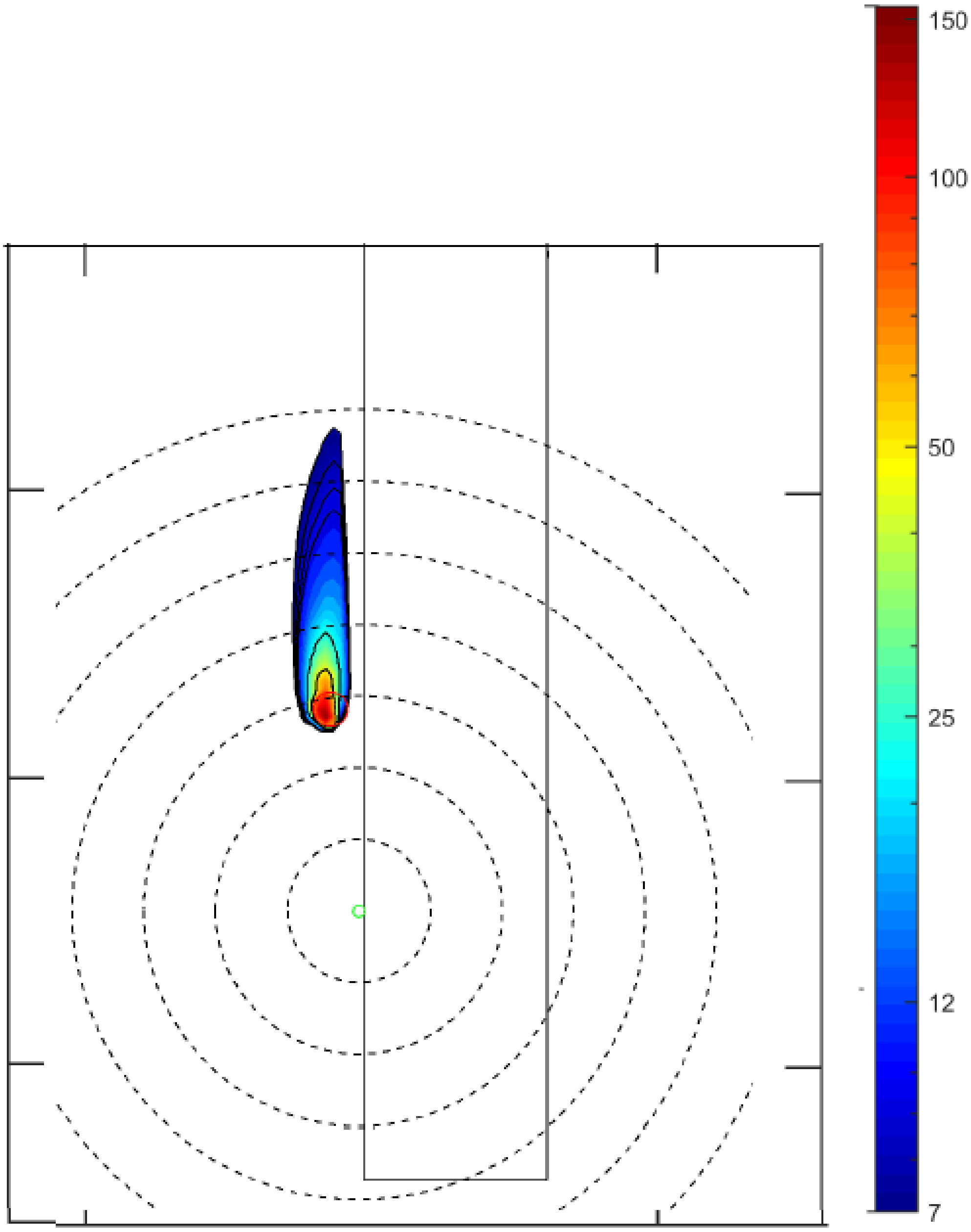

Figure 9-16: Calculation for the field of effect of TPH in the far-field resulting from the PW discharge. The field of effect is illustrated for concentrations > 7 ppb TPH. The key shows ppb. Range rings mark 25 m distances from the source. The red circle indicates the end of the near-field zone. The green circle indicates the location of the PW discharge.

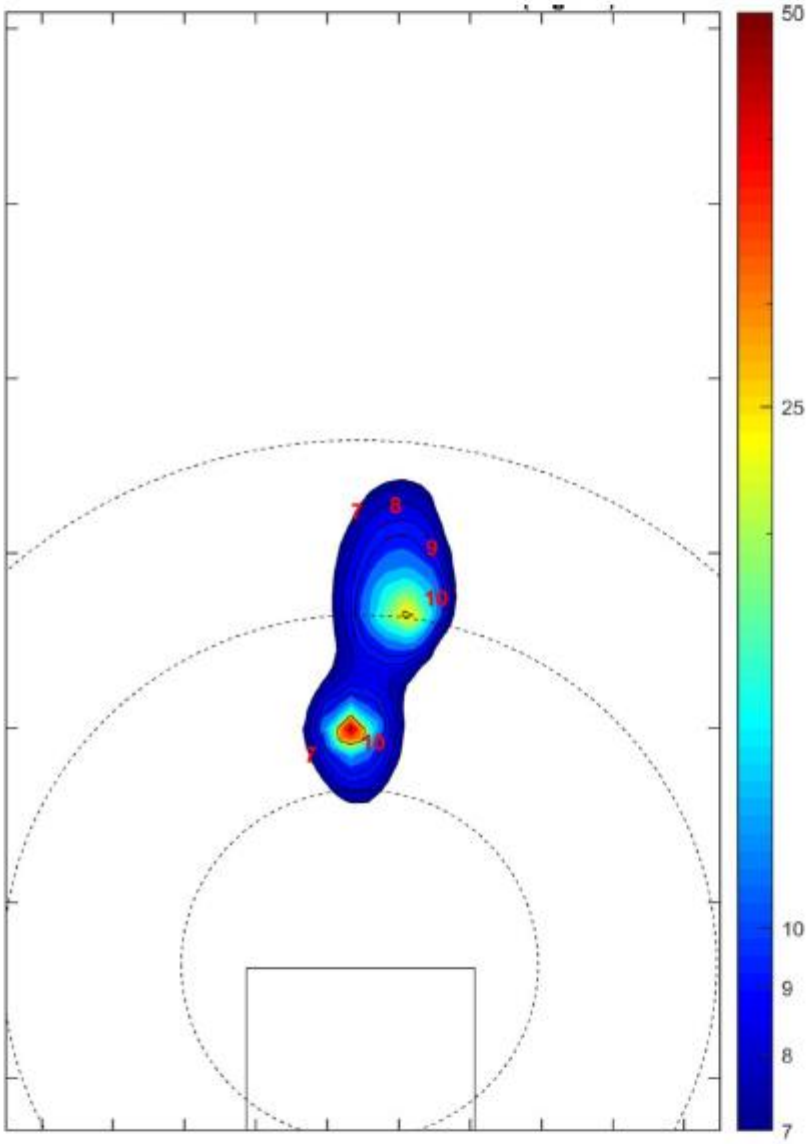

Figure 9-17: Calculation for the field of effect of TPH in the far-field resulting from slops and bilge discharge occurring with all other discharges. The field of effect is illustrated for concentrations >7 ppb. The key shows ppb. Range rings mark 50 m distances from the stern. The gap from the stern represents the length of the near-field zone.

9.10.3.2 Food wastes, sewage and grey water

Discharges will be relatively fresh (less saline) compared with the receiving waters, and therefore positively buoyant and may reach the surface under weaker current conditions. As the plumes will be situated in the upper layer of the ocean, there is potential for the resultant plumes to interact with each other and some of the other defined liquid discharges. Given the high dilution, low volume and low toxicant concentrations, it is not anticipated that food, sewage or greywater discharges would result in any cumulative impacts amongst each other or any other liquid discharge streams.

9.10.3.3 Cooling Water

Generally, the weathervane movement of the FLNG with wind and currents is expected to result in the cooling water flows moving predominantly away from the stern of the FLNG, and therefore with limited potential for interaction with the PW discharge port. The cumulative field of effects and achievement of the defined thresholds for all CW ports is previously discussed in Section 9.10.2.1 Physical Environment and is not repeated here.

In rare cases where the plume may be flowing towards the PW discharge port, the dilution over the >390 m distance prior to interaction will be significant. The plume is likely to be mixing vertically during this flow, and the PW discharge will jet through the cooling water plume, entraining some of the remnant cooling water plume. This may provide an opportunity for constituents in each stream to mix. In particular there may be potential for the formation of chlorides that may precipitate. Chlorine reacts with most metals to form metal chlorides, and so free chlorine has the potential to interact with some constituent metals in the PW discharge should the plumes cross paths under particular current conditions. There is also a possibility of free chlorine reacting with the dissolved aromatic hydrocarbons in the PW discharge. The complexing of metals such as cadmium, lead and nickel with chloride compounds can act to increase or decrease their toxicity to aquatic organisms and the rates of uptake by those organisms, effects which also depend on temperature and salinity. The formation of metal chloride complexes is also affected by salinity, with increasing salinity generally leading to both increased formation and reduced toxicity. Chlorinated aromatic hydrocarbons (such as chlorobenzene) will tend to adsorb to suspended sediments and other matter, and may also bioaccumulate in aquatic organisms.

While these chemical complexes are a potentially toxic hazard to marine organisms, the likelihood of metal chlorides or chlorinated aromatic hydrocarbons being present in significant concentrations beyond the immediate vicinity of the discharge source is considered to be non-credible when the initial pollutant concentrations in the respective discharges and subsequent dilutions prior to interaction are taken into account.

9.10.3.4 Desalination Brine, MBP Effluent and Boiler Blowdown Discharges

As per Section 9.10.2.2 Biological Environment, these discharges are likely to dilute and disperse rapidly. As the plumes are expected to resolve in the upper layer of the water column, interaction with other near-surface discharges and plumes may be possible. However, there will not be any considerable cumulative impacts associated with co-mingling due to the different additives and physical properties not presenting a feasible multiplication effect. RPS (2019b) shows that due to dilutive influences from other larger discharge streams (e.g. cooling water) and low inherent toxicity of any additivies, the defined PNEC thresholds are predicted to be met:

- For boiler blowdown and desalination brine, 108 m and 96 m from the discharge location respectively and <80 m from the FLNG).
- For MBP effluent <65 m from the FLNG).

9.10.3.5 Subsea Valve Discharges

Given the subsea system is located in deep water and a considerable distance from the FLNG, valve actuation discharges are not expected to interact with any other planned discharges and are therefore not considered further from a cumulative impact perspective.

Cumulative Liquid Discharges Impact Summary

The RPS (2019b) modelling assessment shows that the potential cumulative impacts of all liquid discharges released simultaneously are not expected to exceed the predicted impact footprint of the worst-case discharges when assessed in isolation as described earlier in Section 9.9.2, i.e. slight impacts will be contained within the 1 km mixing zone from the FLNG described and assessed for PW as a standalone discharge stream.

Given the open offshore location and absence of particularly sensitive or high-value marine ecosystems or habitats at the FLNG location and within the Operational Area, predicted cumulative impacts to water quality are considered slight (Magnitude -1, Sensitivity - L). Bakke et al. (2013) states that typically no impacts are detected beyond 2 km from offshore facilities around the world noting that the nearest potentially high environmental value habitats that could potentially be affected in proximity to the FLNG are:

- Browse Island (approximately 39 km from the Operational Area)
- Echuca Shoal (approximately 61 km from the Operational Area)
- Continental Slope Demersal Fish Communities (approximately 14 km from the Operational Area).

9.9.4 Impact Assessment Summary

Table 9-43 lists the highest residual impact consequence rankings of the relevant environmental receptor groups.

Table 9-43: Liquid Discharges Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence Ranking
Evaluation – Planned Impacts			
Physical Environment	-1	L	Slight
Biological Environment	-1	L	Slight
Socio-economic and Cultural Environment	NA	NA	NA

9.9.5 ALARP Assessment and Environmental Performance Standards

Table 9-44: Drainage (Slops) and Bilge Waste Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Eliminate discharges from FLNG by storing all open drainage and bilge effluent to be transported and treated /disposed onshore.	No	There are significant costs and HSE risks associated with storing and transporting onshore all open drainage and bilge effluent on the marine support vessels and the FLNG. It is grossly disproportionate to the environmental impacts of onboard treatment prior to discharging overboard.	N/A	N/A	N/A
Substitution	Alternative technology to oil-water separator system.	No	The oil-water separator systems on the FLNG and vessels are standard MARPOL-compliant systems for management of accidentally-oil contaminated drainage and bilge in offshore installations and vessels. On the FLNG there is also an option available to direct off-specification drainage effluent through the MPPE system if required.	N/A	N/A	N/A
	FLNG: Monitoring of drainage and bilge discharges.	Yes	If the online monitor is not functional, manual samples will taken to facilitate determination of oil in water concentration to allow batch discharges to occur where the batch concentration is confirmed below the limit. Discharges at this level are not expected to cause any significant impact to the marine environment given low flow rates and high dilutions close to the source. If the slops open drainage system cannot meet the discharge limit, the effluent can also be routed to the Produced Water Treatment System (MPPE) for further treatment prior to discharge. The Slops Tanks can also act as a further separation	7.1	Drainage effluent will not be discharged via the slops system if 30 mg/L (24 hour average) oil in water limit is exceeded.	Records demonstrate no exceedances of the 30 mg/L (24 hour average) oil in water discharge limit.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			mechanism for treating Produced Water which has a limit to 30 mg/L oil in water over a 24hr average. Oil in water analysis requirements is defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227).			
Engineering				7.2	Bilge effluent will not be discharged if the 15 mg/L oil in water limit is exceeded.	Records demonstrate no exceedances of the 15 mg/L oil in water discharge limit.
Engineering	Marine support vessels Compliance with Marine Order 91 (International Oil Pollution Prevention [IOPP] certificates).	Yes	The marine assurance system is administered by Shell's Marine team and, amongst other requirements, ensures compliance of contract vessels with MARPOL and Marine Order 91. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the relevant AMSA Marine Orders.	7.3	Assurance will be undertaken of marine support vessels, including a check for valid and in date International Oil Pollution Prevention (IOPP) certificates as required by vessel class requirements.	Assurance records
Administrative and Procedural Controls	Spill kits onboard the FLNG and marine support vessels.	Yes	Storage and use of spill adsorbent and clean-up kits are inexpensive and low-maintenance. Accumulations of oil, grease and other contaminants will be collected and removed from the decks.	7.4	Spill kits are available on the FLNG and marine support vessels to clean up small accumulations of contaminants.	Records indicating spill kits are in place.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 11.1.9 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.5	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have	Records demonstrating the chemical selection process outlined in the Chemical Management

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
					a complete ALARP assessment.	Process have been followed.

Table 9-45: Sewage, Grey Water and Food Waste Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	On board storage of sewage, greywater and food wastes for transport to and disposal at an onshore facility.	No	Offers limited environmental benefit, as any changes to water quality beyond a localised mixing zone are likely to have no environmental effect. Is likely to increase operational costs associated with additional transits to and from port and introduce additional safety and environmental risks related to increased transit time and operation of additional vessels, plant and equipment.	N/A	N/A	N/A
Substitution	Use of sewage treatment system to treat all sewage prior to disposal	No	Offers limited environmental benefit, as the addition of chemicals (such as flocculants and defoaming agents) would be required to treat the effluent. Though some reduction in area impacted may occur this benefit is offset against the detrimental addition and increased cost of refined chemicals. Therefore the available environmental	N/A	N/A	N/A

			impact reduction is negligible to non-existent.			
Substitution	Use of alternative treatment technologies	No	• Requires additional cost due to the space requirement onboard vessels and FLNG to enable installation. • Increases operational costs for maintenance and staffing due to performance challenges associated with these technologies (e.g. clogging of membranes/screens). Also increases potential exposure of the workforce to pathogens associated with these waste streams.	N/A	N/A	N/A
Engineering	FLNG: Food waste will be reduced to <25mm particle size prior to discharge to sea	Yes	Food wastes are macerated to less than 25mm diameter prior to discharge within 500m of the FLNG. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and AMSA Marine Order 95.	7.6	Food macerator is maintained in accordance with the MMS to reduce food waste to < 25 mm particle size prior to discharge to sea.	Maintenance Records
Engineering	FLNG: Vaccume Toilets	Yes	Reducing the particle size will aid in the rapid dispersion and biodegradation of this waste stream. Sewage will be reduced to <25mm particle size prior to discharge to sea.	7.7	N/A	N/A
Engineering	Further treatment e.g. disinfection of the waste-stream prior to discharge	No	There are no known sensitive receptors to human pathogens in the vicinity of the discharge location that may be impacted therefore disinfection of the waste stream is not considered to provide a reduction in the impact. Additionally, not dosing the waste stream with a disinfectant such as chlorine will avoid potential cumulative impacts with other chlorine dosed streams such as cooling water.	N/A	N/A	N/A

			Furthermore, the consumption of disinfection chemicals, the resources consumed to transport the chemicals, and the risk of excess chlorine being released into the sea outweighs the negligible environmental benefits of disinfecting treated sewage effluent prior to discharge.			
Engineering	The marine assurance system is administered by Shell's Marine team and, amongst other requirements, ensures compliance of contract vessels with MARPOL, and Marine Order 96.	Yes	This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the relevant AMSA Marine Orders.	7.8	Assurance will be undertaken of marine support vessels to check for valid and in date International Sewage Pollution Prevention (ISPP) Certificates, as required by vessel class requirements.	Assurance records
Administrative and Procedural Controls	Required marine support vessels will maintain a Garbage Management Plan (or equivalent)	Yes	Each required vessel has its own Garbage Management Plan/Procedure (or equivalent) to manage wastes generated and stored onboard. All wastes that are not permitted for discharge are sent ashore for reuse, treatment, recycling and/or disposal as appropriate. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and AMSA Marine Order 95.	7.9	Marine support vessels (to which MARPOL Annex V / Marine Order 95 applies) have a current Garbage Management Plan (or equivalent).	Garbage Management Plan (or equivalent) is sighted onboard marine support vessels and are maintained up to date.

Table 9-46: Cooling Water Discharges ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Cooling is required for the FLNG facility from a safety and technical integrity perspective as part of the hydrocarbon production process and associated utilities	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			for personnel. As such, cooling water discharge cannot be avoided. Collecting, storing, and transporting all CW discharges to shore is not a reasonably practicable alternative, due to technical, financial, and health and safety costs.			
Substitution	Use of air-cooling instead of cooling water	No	Although air cooling is a technology tested for most onshore LNG facilities, water cooling is assessed as more efficient for the offshore FLNG facility. Air-cooling would require additional energy (fuel gas burnt) and equipment which will not fit on the FLNG from a structural perspective. The discharge of recycled seawater poses minimal environmental impact vs. burning more fossil fuels. The use of air for cooling also doesn't completely eliminate the requirement for seawater discharges.	N/A	N/A	N/A
Substitution	Use alternatives to hypochlorite	No	Hypochlorite is produced on the platform from seawater via the seawater intakes and is used to prevent biofouling to ensure the continued operability and integrity of the seawater system. Other chemicals were considered during the design phase of the Project but ruled out for technical, commercial, logistical and safety risk associated with transporting, handling and storing the quantity of chemicals required. This transporting, storing and handling risk is grossly disproportionate to the negligible environmental gain of substituting the hypochlorite discharge for a different chemical. Hypochlorite is be readily	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			generated from seawater which eliminates this risk.			
Substitution	Use of alternative systems for biofouling control	No	Copper-chlorine system: This process utilises sodium hypochlorite (generated as for electrochlorination) with the toxicity to fouling organisms boosted by copper ions generated in a dosing chamber from sacrificial copper electrodes. The copper and chlorine act on the cell membranes of the fouling organisms. Due to the synergy of their action, dosage requirements are significantly reduced (approximately 5 ppb copper and 50 ppb hypochlorite). Levels of copper from anti-biofouling systems have been measured by the US Uniform National Discharge Standards (UNDS) Program (US EPA [1999]). Their research has shown that the concentration of copper discharged from anti-biofouling systems is between 0.52 and 0.69 ppb which is above the ANZECC (2018) DGV for copper which may introduce additional environmental risk in isolation or cumulatively with chlorine as an additive effect. Copper-aluminium-chlorine system: This process is similar to the copper-chlorine process. The major difference is that the seawater is passed through an ion vessel that uses an impressed current method to selectively dissolve copper and aluminium. This is again mixed with sodium hypochlorite prior to dosing the system. So	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			although the concentration of residual chlorine could be reduced by the use of copper-chlorine or copper-aluminium-chlorine systems, there is potentially no environmental benefit gained as it introduces additional contaminants that are toxic.			
Engineering	Chlorine neutralisation (Dechlorination)	No	Dechlorination is the process of removing residual (free) chlorine from disinfected wastewater prior to discharge into the environment. This process reduces the effect of potentially toxic disinfection byproducts by removing the free/residual chlorine remaining after chlorination. Further engineering changes to provide additional treatment prior to the final discharge, would require additional equipment, imposing significant additional space and weight requirements, which are not available on the FLNG from a structural perspective. Furthermore, with major financial costs, for negligible environmental benefit at this location given the slight residual environmental impact presented by the resultant plume. Treatment of the CW prior to discharge introduces additional safety risk associated with transporting, handling and storing the quantity of de-chlorination chemicals required which is grossly disproportionate to the negligible environment benefit that may be gained.	N/A	N/A	N/A
Engineering	Chlorine Adsorption	No	Carbon adsorption is usually implemented when total dechlorination is desired. Carbon	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			adsorption can be an effective dechlorination method, but is impractical on on an FLNG scale whereby numerous carbon filters would be required to treat a throughput of ~80,000m^3/hr. Not only will this be impractical from a space / structural perspective on the FLNG, filtering seawater (which contain salts and impurities) would constantly block the filters, requiring frequent change outs and generation of additional waste. Furthermore, this option introduces capital, ongoing costs and waste grossly disproportionate to the negligible environmental gain of further reducing chlorine concentrations in the CW streams.			
Engineering	Additional residence time and/or treatment prior to discharge	No	Further engineering changes to provide additional treatment and/or storage prior to the final discharge, would require additional equipment, imposing significant additional space and weight requirements. Based on the residence time required in a vessel, with the throughput of ~80,000m^3/hr, a vessel of 320,000m^3 (greater than the volume of all of Prelude's 6 LNG Tanks) is required on which is not feasible to retrofit onto the FLNG for negligible environmental benefit at this location given the predicted impact footprint is already small and very localised.	N/A	N/A	N/A
Engineering	Supply of colder seawater sourced from 150m water and use as a cooling medium for the	Yes	At a depth of 150 m, the sea water supply for SW2 is nearly constant at a temperature of 21-22°C resulting in a lower temperature	N/A	N/A - The design features of the CW system were selected, installed and	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	main process cooling requirements.		delta for discharges from this system relative to ambient seawater temperature compared to the scenario of warmer CW being drawn from nearer the surface. Taking this quantity of seawater 150m below surface rather than at surface is novel for FLNG from a design, construction and installation perspective and enhances the energy efficiecy of the facility (i.e. reduction in the GHG emissions footprint, refer to Section 8.12).		commissioned at the time this EP commenced, and are therefore not described in further detail here as an EPS.	
Engineering	Electro-Chlorination System (ECU)	Yes	The ECU is maintained to ensure the chemical dosing of the cooling water system is undertaken in a controlled manner to optimise dosage to the amount required to achieve treatment efficiency. This will include flushing lines as part of ECU shutdown operations. A trial of line flushing as part of an ECU shutdown operation was completed on 25 Aug 2019 to prevent the build up of hypochlorite in the system and prevent blockages. The associated restart on 4 Sep 2019 showed no exceedances as part of the restart sequence. This practice will be carried forward to future ECU shutdown operations and documented in the Seawater Fouling Inhibition Shutdown for Maintenance Procedure.	7.10	The ECU is maintained in accordance with the MMS to ensure dosing is undertaken in a controlled manner	Maintenance Records

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	Online chlorine analysers	Yes	Online chlorine analysers are maintained to ensure availability and measurement accuracy is within acceptable tolerance limits.	7.11	Online chlorine analysers are maintained in accordance with the MMS	Maintenance Records
			As per the Alarm Management Manual, Critical Alarms are red flashing with an audible tone and the response principle is "Immediate emergency corrective actions for the operators to perform to get the variable back within its Critical Limit as stored in the Variable Table (VT)." For residual chlorine alarms, examples of the VT operator actions may include: 1. Confirm shock dosing is not in progress 2. Adjust injection rate if required 3. Verify hypochlorite injection control valve on SW1/2/3/4 inlet is functioning correctly.	7.12	Online chlorine analysers will have associated Critical Alarms at defined limits with defined operator response requirements.	Control logic documentation and monitoring records
Administrative and Procedural Controls	Prelude FLNG Liquid Discharge Monitoring and Management Procedure	Yes	Monitoring of cooling water and adaptive management will be undertaken to ensure that the chlorine concentration targets and limits are met or exceedences are appropriately managed. Surveillance monitoring of environmental discharge limits with pre-determined troubleshooting actions will help reduce the frequency and duration of any exceedances. Consideration of an instantaneous limit of 0.2 mg/L was made. However, this was not practicable due to the requirement for shock dosing to maintain integrity and efficiency of	7.13	Conduct online monitoring or manual sampling (once per 24 hours providing access is safe for sampling and analysis) to confirm chlorine discharge does not exceed a monthly 95th percentile of 0.2 mg/L or instantaneous limit of 0.6 mg/L (calculated per discharge port).	Monitoring records.

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			the system. Shock dosing typically takes place twice a day but may occur more frequently if required for integrity maintenance purposes. The short duration of shock dosing and potential elevation in discharged free chlorine concentrations are not predicted to result in a significant increase in environmental impact.			
Administrative and Procedural Controls	Decreasing the chlorine dosing level of the CW	No	The hypochlorite dosing range and subsequent residual chlorine discharge typical concentration target of <0.2 mg/L with routine shock dosing of up to 0.6ppm is selected to ensure the chlorine concentration is sufficient to prevent biofouling throughout the seawater system. Decreasing the dosing concentration can potentially allow biofouling to proliferate in the pipework. This can compromise the integrity and functionality of the water systems, leading to significant technical issues, and increased risk of loss of hydrocarbon containment scenarios, with intolerable safety risks, as well as increased potential environmental release scenarios to the marine environment. Fouling of the system would also decrease the energy efficiency of the facility resulting in higher volumes of GHG production.	N/A	N/A	N/A

Table 9-47: Desalination Brine, MBP and Boiler Blowdown Effluent Discharge ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	The use of the seawater distillation system and discharge of boiler blowdown water are common and accepted practice for vessels and offshore oil and gas facilities. Offshore activities cannot operate without fresh water.	N/A	N/A	N/A
Substitution	Source all freshwater from onshore.	No	The elimination of the desalination plants to prevent the generation of brine water and MBP effluent would shift the sourcing of water to an onshore resource to 100%. This would increase demand on onshore water supply sources (e.g., Darwin or Broome). It would also result in a high number vessel movements between the FLNG and port, resulting in increased personnel hours (and therefore cost) and increased diesel use (increased air emissions, waste water discharges [including brine water] and cost). The increased financial and environmental cost of this substitute measure is not commensurate with the low environmental impact of brine and MBP effluent discharges.	N/A	N/A	N/A
Engineering	Storing waste effluent onboard and transporting for onshore treatment and/or disposal.	No	Storing on-board and then transferring it to shore results in increase personnel and environmental costs associated with more vessel movements (as outlined in ‘substitute’), and is not possible given that the required storage space would not be available on the FLNG and marine support vessels.	N/A	N/A	N/A
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 11.1.9 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.14	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
						Process have been followed.
Administrative and Procedural Controls	The boiler blow-down and neutralisation tank discharges are monitored either by online analyser or manually for pH.	Yes	pH is monitored to measure the efficiency of each system and to understand neutralisation requirements prior to discharge.	7.15	The boiler blow-down and neutralisation tank discharges are discharged within a pH 6-12 range. These pH analysers are maintained in accordance with the MMS	Pi system records online monitoring of pH when analyser is available or laboratory records

Table 9-48: PW Discharge ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Re-injection of produced water.	No	Assessment of onboard treatment and overboard disposal versus produced water re-injection was undertaken during the design phase of the project. The assessment supported the use of the onboard treatment based on the following: • Produced water reinjection systems require significant additional capital and operational expenditure with an associated increase in manning levels. • Produced water re-injection pumps are a source of high noise levels in their immediate vicinity and contribute to the overall noise footprint. • Lower power demand for the onboard treatment versus reinjection, therefore lower CO_2 emissions. • For the reinjection option, the produced water treatment facilities remain the same, in line with overboard disposal,	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			due to capability of overboard disposal in case the water re-injection system is down, therefore, there are no equipment reduction benefits for the re-injection option. According to other facilities worldwide, re-injection facilities have on average 80% availability. • There is potential risk of reservoir souring/scaling due to water re-injection. The availability of reservoir for re-injection near the Prelude field without fracking or souring is very limited. • Only slight residual environmental impact exists from the onboard treatment and overboard disposal due to high quality water treatment technology chosen.			
Elimination	Storage, treatment and disposal (without discharging) during well clean up.	No	All feasible alternatives/options would result in significant additional safety, environmental, logistical, operational and financial costs. These costs would primarily relate to the storage requirements of the well clean-up fluids on the FLNG (as opposed to discharging), prior to transport to shore. To enable storage, extra tanks would be required on the FLNG, imposing additional space and weight requirements for the well clean-up fluids. Modifying the FLNG to allow temporary storage of well clean-up fluids, would require significant financial expenditure. Transferring the tanks to support vessels would require increased handling and lifting operations, therefore exposing personnel to health and safety risks. Additionally, limited onshore facilities are available to treat, recycle, and/or dispose of such fluids. The potential environmental benefit is the elimination of the temporary and short-term changes to water quality around the FLNG and therefore reducing the potential exposure to pelagic communities (note the clean-ups are typically one to four days per well). However this environmental benefit is considered disproportionate to the (technical, financial	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			and safety) costs associated with engineering extra storage or additional treatment facilities requirements on the FLNG, the additional transfers and the burden of onshore treatment, at limited facilities. Therefore, the significant costs of storing, additional treatment and/or disposing of the fluids are grossly disproportionate to the negligible environmental gain (of avoiding the short-duration well clean-up discharges) and are not considered a reasonably practicable alternative.			
Substitution	Alternative technology to MPPE system.	No	The MPPE technology was chosen based on a Best Available Technology (BAT) assessment during the design phase of the project. Alternatives to MPPE are steam stripping, adsorption to activated carbon, advanced filtration, bio-treatment, the use of hydrocyclones, Induced Gas Floatation (IGF), advanced oxidation or sent to shore. The MPPE was listed as BAT by the OSPAR convention for the protection of the marine environment of the North-East Atlantic (1999) for produced water management on offshore oil and gas platforms based on the following: • Unlike other methods, MPPE technology removes dispersed and dissolved components effectively • The effective reclamation procedure of the MPPE material makes it suitable for removal of high quantities of dispersed and dissolved hydrocarbon from wastewater but without the generation of significant waste streams (e.g. spent adsorbents). • The MPPE technology has an effective regeneration process such that one column can operate automatically while another column is regenerating at the same time.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			• The MPPE unit operates automatically and operator attention is limited.			
Engineering	MPPE Treatment System	Yes	The produced water treatment system is designed and warranted by the vendor to meet a limit of 30 mg/LTPH over 24hr average and 42mg/L TPH instantaneous. Given the slight predicted residual impacts of these concentrations and alignment with international standards, it is an appropriate maximum limit for TPH for Prelude. High availability of the system ensures that incidents of non-compliant discharge are minimised if not prevented. The change-out of the MPPE columns is included in the maintenance program. Two by 100%-capacity MPPE systems are installed on the FLNG (one in extraction, one in regeneration and two in stand-by) to ensure high availability of the system. MPPE columns are anticipated to be sent onshore for media replacement every 2 to 4 years during normal operations. Furthermore, a buffer tank with ~5400m3 capacity is also provided in case of system downtime or if re-treatment of off-specification water is required. Further redundancy is provided by the option to route the PW to the Slop system in the event that the MPPE system is not available. The system is implemented on two conditions during normal operations (i.e. not during well clean-up activities); 30mg/L (24hr average) and 42mg/L (instantaneous). The automatic switch-off within the system allows for the daily average limit to be met. Off-specification water is redirected inboard when predefined alarm limits are reached.	7.16	The discharge of the produced water shall have a TPH not exceeding 30 mg/L (24-hour average) and 42 mg/L (instantaneous), except during well clean-ups.	Records of TPH in PW maintained to verify that the concentration of TPH in PW meets requirements.
Engineering	MPPE Treatment System	Yes	Well clean-up: The TPH content of the PW is not to exceed 100mg/l averaged over any 24-hour period during well cleanups. The 100 mg/l is the expected worst-case discharge during these clean-up periods given the PW water is settled in the buffer tank	7.17	During well clean-up activities the produced water shall have a TPH not exceeding 100 mg/L (24hr average).	Records of TPH in PW maintained to verify that the concentration of

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			to remove most dispersed oil from the PW before treatment through the MPPE system.			TPH in PW meets requirements.
Engineering	Online OIW Analyser: Verification and validation of the OIW analyser.	Yes	The online OIW monitor provides information on the performance of the PW treatment system needed to help ensure discharge limits are being achieved. Verification, validation and maintenance of the OIW analyser ensures that the monitor is operating within an acceptable tolerance of accuracy. Oil in water analysis requirements is defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227).	7.18	Vertify that the PW online analyser weekly until the operator statistical quality control principles are fulfilled and then at least monthly thereafter to ensure readings are not outside of nominated tolerance limits.	OIW analyser verification records
Engineering	Manual PW Sampling Procedure	Yes	There may be cases when OIW analysers may not be available due to maintenance or downtime. Back up manual sampling and analysis will be required in these situations. This will be covered by the laboratory sampling and analysis regime defined in Prelude FLNG Oil in Water Analysis Terminology and Methodology (HSE_PRE_16227). An internationally recognised method such as ASTM D 7678-11, ISO 9377-2:2000 or equivalent for TPH determination will be used for routine oil in water determination in the lab. 6 hourly sampling during discharge is deemed representative as well as considered a practicable level to ensure sampling and analyses personnel are able to fulfil all of their other roles and responsibilities. Depending on the result from manual testing, operations will decide whether to continue operation or to stop discharge and operate the system in a batch process. The PW will be collected in the buffer tank, and appropriate number of samples (based on the total volume) will be collected and analysed to ensure compliance with the limits before discharging. Note that if batch process is undertaken, no further sampling will be done during	7.19	When discharging PW, if online analyser is not available; conduct manual lab analysis approximately 6 hourly. Results will be used to verify that the PW TPH concentration does not exceed the defined limits.	Sample records

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			discharge, provided aforementioned testing is completed and concentrations are deemed acceptable for discharge.			
Administrative and Procedural Controls	Prelude FLNG Liquid Discharge Monitoring and Management Procedure	Yes	The procedure provides for implementation of a risk-based adaptive monitoring and management program for liquid discharges. It relates to the adaptive monitoring and management framework described in Section 10.4.1.2. The program comprises several components for PW, including: Topsides monitoring, analysis, and review Whole Effluent Toxicity (WET) testing Field monitoring Model prediction verification Contingency/management actions, as required The program ensures the extent and effect of the PW discharge and associated contaminants are assessed, and where practicable, allows adaptive management changes to occur.	7.20	95% species protection will be maintained 95% of the time for water quality beyond the 1km mixing zone for PW discharges.	Monitoring, modelling, adaptive management and/or other assessments demonstrate that 95% species protection is maintained 95% of the time outside of the defined PW mixing zone.
Administrative and Procedural Controls	Shell Chemical Management Process.	Yes	Following the chemical management process as detailed within Section 11.1.9 will minimise the impact of those chemicals which are used and discharged to ALARP levels.	7.21	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.
Administrative and Procedural Controls	Maintenance of PW System	Yes	Documented maintenance program is in place for key PW equipment on facilities that provides a status on the maintenance of equipment. Through ongoing maintenance, the operability of the relevant systems and equipment is optimised, reducing the risk of inadequate PW treatment, monitoring and management.	7.22	The following PW related equipment is maintained as per the MMS: • MPPE columns • OIW online monitor	Maintenance of PW System

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
					• PW Flowmeter	

Table 9-49: Use and Discharge of Ad-Hoc Chemicals ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	The use of chemicals cannot be eliminated from the operation, preservation and maintenance of the FLNG, subsea facilities and support vessels.	N/A	N/A	N/A
Substitution	Selection of alternate chemical products	Yes	Chemicals planned for discharge have been selected for inclusion based on safety, technical, environmental and commercial performance. The use of alternative chemicals is considered in each assessment as part of the Chemical Management Process (Section 11.1.9). If technically sound, lower cost and lower environmental risk chemicals are identified in the future, then they will go through the assessment process and selected for use where practicable.	7.23	Annual review of chemicals potentially discharged.	Record of annual production chemical review
Engineering	The subsea facilities are designed to minimise release of fluids to the environment	Yes	Because of the design, only incidental releases during valve actuations, tie-ins and connections and during subsea interventions are expected.	7.24	Subsea actuation valves are maintained per MMS	Records from MMS
Engineering	Equipment to capture or collect subsea discharges	No	No practicable engineering controls are available that are proven to be able to capture or contain subsea discharges. Designing and installing a temporary capture system would result in significant financial costs, with technical uncertainty, grossly disproportionate to any slight increase in	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			environmental benefit of preventing small and infrequent discharges.			
Administrative and Procedural Controls	Shell MOC Manual	Yes	Re-processing or onshore disposal of chemically dosed liquids may be a practicable control measure for certain activities or circumstances. This will be assessed on a case-by-case basis and documented accordingly via the MOC process (Section 10.1.9). Any fluid discharges as a result of the activities would be controlled and minimised through the system isolations prior to conducting the activity, thereby limiting the potential discharge volumes to that which is contained within the targeted and isolatable section of the containment vessel. The MOC will detail any isolation steps for the specific components of the system before activities commence to reduce resultant discharge volumes to ALARP.	7.25	Ad Hoc/Non-routine discharges with chemical additives are assessed and approved through the Shell MOC Manual prior to release.	Records of completed and approved MOCs
Administrative and Procedural Controls	Infield water quality monitoring of Ad-Hoc, IMR, installation and/or commissioning based discharges	No	Infield water quality monitoring could be used to verify the predicted low risk associated with minor amounts and low frequency of IMR, installation and/or commissioning fluids planned to be discharged to the ocean. Monitoring could not be used to inform adaptive management of these discharges due to their intermittent/infrequent occurrence over short periods (typically minutes to hours). Given the typically low volumes, concentration and frequencies of the discharges and the slight associated residual impacts, it is not considered to be practicable to undertake infield monitoring as the cost (financial and safety) of implementation is grossly disproportionate to any potential further reduction in environmental impact.	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Related ALARP Discussion and Alternate, Additional or Improved Control Measures Considered	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Shell Chemical Management Process	Yes	Following the chemical management process as detailed within Section 10.1.10 will minimise the impact of those chemicals which are used and discharged to ALARP levels. All chemicals planned for discharge will be selected, assessed, approved and managed on a case-by-case basis in accordance with the Shell Chemical Management Process to ensure they present the lowest environmental risk practicable. This process is used to demonstrate that the potential impacts of the chemicals selected are acceptable, ALARP and not contrary to this EP, as detailed further in Section 10.1.10. Additionally, non-routine, temporary, ad-hoc and/or contingency chemical discharges associated with the FLNG, subsea facilities or support vessels will also be subject to application of the Shell MOC Manual detailed in Section 10.1.9 as a further control. This will ensure that additional focus is provided on such discharges to ensure they are ALARP, acceptable, optimised and the available alternatives are adequately considered.	7.26	Chemicals that are planned for discharge to sea are substitution warning free and Gold, Silver, D, or E rated through the OCNS, or are PLONOR (listed by the OSPAR Commission), or have a complete ALARP assessment.	Records demonstrating the chemical selection process outlined in the Chemical Management Process have been followed.

9.9.6 Acceptability of Impacts

Table 9-50: Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Water Quality	No significant impacts to water quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Liquid discharges have the potential to result in reduced water quality in the immediate vicinity of the discharge location, however discharges will rapidly dilute and disperse in the open ocean environment. Modelling studies indicate impacts to water quality are likely to be highly localised around the discharge locations, which is consistent with industry monitoring studies and demonstrates high confidence in the assessment that ecological integrity, social amenity and human health values will not be significantly impacted.
	Sediment Quality	No significant impacts to sediment quality and quality is maintained so that biodiversity, ecological integrity, social amenity and human health values are protected.	Yes	Liquid discharges may result in a slight decrease in sediment quality at locations around the FLNG over a long timeframe (in the order of 10's of years). For the duration of this EP though, elevations of contaminants in sediments surrounding the FLNG will not be detectable with statistical certainty beyond background levels. Therefore, there is high confidence in the assessment that biodiversity, ecological integrity, social amenity and human health values will be protected at all times.
Biological Environment	Benthic communities	• No significant direct impacts to bare sediment benthic habitats as a result of the petroleum activities which adversely effects biological diversity or ecological integrity. • No direct impacts to high-value sensitive benthic communities (corals, macroalgae, seagrasses and mangroves) associated with named reefs, banks and shoals.	Yes	
	Pelagic communities (Non-Threatened or Migratory)	No significant adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.	Yes	Modelling studies indicate that impacts to water quality will be localised around the FLNG which is characterised as open offshore waters, typical of the offshore Browse Basin. Given the transient nature and absence of important habitat and ecological assemblages of pelagic species, there is high confidence that potential impacts to pelagic communities within a 1 km mixing zone are considered acceptable given there will not be any significant

				adverse effect on pelagic communities, populations, habitats or spatial distribution of a species.
	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations (Refer to Table 8-1).	Yes	Most threatened and/or migratory fauna species within the area predicted to be influenced by the planned liquid discharges are air breathing vertebrates, which are unlikely to be directly affected as their skin is relatively impermeable and they breathe air. Hence, direct impacts are not considered credible. Non-air breathing species are not anticipated to be present in significant numbers nor be exposed to levels that may adversely impact on individuals and therefore there will be no significant impacts.
	Commonwealth Marine Area	No significant impacts to the Commonwealth Marine Area (Refer to Table 8-1).	Yes	Liquid discharges may result in a slight decrease in water quality in the immediate surrounds of the discharge points and sediment quality at locations around the FLNG over a long timeframe (in the order of 10's of years). For the duration of this EP though, elevations of contaminants in sediments surrounding the FLNG are not predicted to be detectable with statistical confidence beyond background levels and hence remain well below levels known to cause deleterious effects. Therefore, there is high confidence in the assessment that the following relevant significant impact criteria will not be breached: • Substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or • Persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected. Hence, the highly localised impacts predicted from liquid discharges will not credibly exceed the MNES significant impact criteria for the Commonwealth Marine Area as listed in Table 8-1.
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of impacts from liquid discharges determined the residual ranking of slight or lower (Table 9-43). As outlined above, the acceptability of the impacts from liquid discharges associated with the petroleum activity have been considered in the context of:

Principles of ESD

The impacts from liquid discharges are consistent with the principles of ESD based on the following points:

- The environmental receptors within the Operational Area and defined mixing zones are not expected to be significantly impacted; and
- The precautionary principle has been applied, and studies (e.g. modelling assessments, WET testing, literature reviews and statistal data analyses) undertaken where knowledge gaps were identified.

Relevant Requirements

Management of the impacts from liquid discharges are consistent with relevant legislative requirements, including:

- Compliance with international maritime conventions, including:
  - MARPOL:
    - Annex I: regulations for the prevention of pollution by oil
    - Annex II: regulations for the control of pollution by noxious liquid substances in bulk
    - Annex III: regulations for the prevention of pollution by harmful substances carried by sea in packaged form, and
    - Annex IV: regulations for the prevention of pollution by sewage from ships
    - Annex V: (regulation for the prevention of pollution by garbage from ships).
- Compliance with Australian legislation and requirements, including:
  - Navigation Act 2012 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983:
    - Marine Order 91 (Marine pollution prevention – oil)
    - Marine Order 93 (Marine pollution prevention – noxious liquid substances)
    - Marine Order 94 (Marine pollution prevention – packages harmful substances)
    - Marine Order 95 (Marine pollution prevention – garbage)
    - Marine Order 96 (Marine pollution prevention – sewage).
- Management of impacts and risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-51)
- Implementation of recognised industry standard practice, such as:
  - Treatment of PW to the defined limit of 30 mg/L daily average exceeds the performance recommended by the IFC EHS guidelines for Offshore Oil and Gas Development (2015) where discharge to sea is allowed if oil and grease content does not exceed 42 mg/L daily maximum, i.e. mean level for any given day in the month assessed does not exceed 42 mg/L.
  - Treatment of collected drainage bilge water to < 15 mg/L residual oil.
  - IFC (2015) standard for water temperature which requires that the effluent should not result in a temperature increase of greater than 3°C compared to the ambient temperature at the edge of a defined mixing zone (100 m in this EP).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of liquid discharges impacts indicates significant impacts to threatened and migratory species will not credibly result from the liquid discharges aspect of the Prelude petroleum activities.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-51.

Commonwealth Marine Area

The impacts and risks from the liquid discharges aspect of the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 9-51.

Table 9-51: Summary of Alignment of the impacts from the Liquid Discharges Aspect of the Prelude Petroleum Activities with Relevant Requirements for MNES

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species Table 8-1)	The application of the Shell Chemical Management Process and proposed management controls for liquid discharges reduces the impact of toxic pollutants being introduced into and/or persisting in the marine environment. An environmental monitoring adaptive management program has been developed for liquid discharges as described in Section 10.4.1. This program will seek to demonstrate that the actual levels of recorded impacts for key discharges do not exceed those which were predicted within the impact assessment presented in this EP. If recorded impact levels do exceed those described, this would trigger the adaptive management process and assessment under the Shell MOC Manual (Refer to Section 10.1.9)
	Conservation advice on Balaenoptera borealis (sei whale) (DoE 2015c)	
	Conservation advice fin whale (Balaenoptera physalus) (DoE 2015d)	
	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017a)	
	Conservation advice on Rhincodon typus (whale shark) (DoE 2015e)	
Wetlands of International Importance	N/A	N/A
Commonwealth Marine Area	Significant impact guidelines for Commonwealth marine environment (Table 7-1)	Water quality impacts by planned liquid discharges are expected to be limited to within 1 km of the FLNG for all collective discharge streams. Impacts confined within this area are not considered to be significant in the context of the significant impact criteria for the Commonwealth Marine Area given the nature and scale of the impacts and the characteristcis of the local receiving environment (open offshore waters with regionally well represented soft and bare sandy sediments). The impact assessment indicates the impacts associated with the discharge of liquid discharges will not result in a significant adverse impact on marine ecosystem functioning/integrity, social amenity or human health.

		Shell has sought to reduce potential impacts through the selection and implementation of the controls and EPSs listed in Section 9.9.5.

External Context

There have been no objections or claims raised by Relevant Persons in preparation of this EP around the liquid discharges aspect. Shell's ongoing consultation program will consider objections and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of impacts and risks from liquid discharges determined the residual impacts rankings were slight or lower (Table 9-43). As outlined above, the acceptability of the impacts have been considered in the context of:

- The established acceptability criteria for the liquid discharges aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual impacts of slight or lower to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the liquid discharges aspect.

The evaluation above in section 9.9.2 and 9.9.3 provide high confidence that any cumulative liquid discharge impacts within 1 km of the FLNG facility will afford sufficient and acceptable ecological protection.

Based on the points discussed above, Shell considers the impacts from liquid discharges associated with the Prelude project to be acceptable.

9.9.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No significant impacts to water quality from liquid discharges from the Prelude asset.	Demonstrated implementation of EPSs for discharge of liquid effluents
No impacts to sediment quality from liquid discharges from the Prelude asset.	
No impacts to any KEFs surrounding the Prelude facility.	

No injury or mortality of listed Threatened or Migratory MNES species as a result of discharge of liquid effluent.	
No impacts to coral reefs occuring at Browse Island or nearby Shoals (Echuca/Heywood).	

9.10 Atmospheric Emissions

9.10.1 Aspect Context

Emissions of atmospheric pollutants (e.g. nitrogen oxides, sulfur oxides, carbon monoxide and particulate matter), air toxics (e.g. benzene, toluene, xylene, formaldehyde, etc) and other harmful to human health gases (e.g. hydrogen sulfide) have the potential to impact local and regional air quality. The main sources of such emissions for Prelude FLNG operations include:

- Combustion of gas for power generation
- Flaring of hydrocarbon for process safety purposes
- Venting of reservoir CO_2
- Fugitive emissions / General Leaks
- Combustion from transportation – e.g. vessels supporting the FLNG operations.

Sources of internal combustion emissions in the Operational Area include:

- Propulsion and electricity generation engines on marine vessels and helicopter operations supporting Prelude operations. Operations support marine vessels include dedicated supply vessels, infield support vessels/ pilot tugs and campaign specific vessels (e.g. IMR vessels).
- Propulsion and electricity generation engines of LNG, LPG and condensate carriers.
- The seven (7) 200MW each dual fuel (fuel gas and diesel) High Pressure Steam (Marine) Boilers on the FLNG, running on fuel gas during normal operations in a 6 + 1 configuration. These boilers produce steam for use as a heat source to the process and to turn steam turbines for power generation and process compressors.
- The three (3) Essential 7.68 MW Marine Diesel Generators (MDGs) providing power for black start operations and to bring the process to a safe condition during any major power upsets and supply essential power consumers in the event of a complete plant shutdown. These are offline during normal operations.
- The two (2) SOLAS designated Emergency Diesel Generators (EDGs) (1 x 1250 KW and 1 x 750 KW) which supply electricity to SOLAS critical equipment (e.g. control and safety systems, navigational aids, fire-fighting pumps, etc.). These are offline during normal operations.
- Additional sources of internal combustion emissions over the life of the facility and field include accommodation support vessel(s) during maintenance shutdowns and additional vessel visits supporting these campaign events. These will occur periodically and result in additional emissions for the duration of the campaign.

Flaring emissions include the following point sources:

- Warm Wet High-Pressure Flare (A-63001)

- Cold Dry High-Pressure Flare (A-63002)
- Cold Dry Low-Pressure Flare (A-63003)
- Warm Wet Low-Pressure Flare (A-63004).

Under routine operating conditions and without any process upsets or passing valves, the flares burn a small stream of fuel gas intended to maintain flares lit at all times (i.e. fuel gas to flare pilots). This stream forms part of routine flaring, which is estimated at 2053 kg/h in total for all Prelude flares. The key pollutant emissions from flaring include NO_x, SO_x, CO, $PM_{2.5}$ and PM_{10}, as well as minor quantities of air pollutants such as benzene, toluene and formaldehyde.

Removed reservoir carbon dioxide (acid gas) is disposed continuously through the dedicated Prelude acid gas vent whilst the facility is producing. The acid gas composition consists of more than 98% CO_2, with the remainder being minor quantities of CH_4, H_2S and BTEX (benzene, toluene, ethylbenzene and xylenes). The main concerns associated with these constituents are occupational health impacts to the worker population at the FLNG in the unlikely case of acid gas plume backwash onto work areas on the vessel. Risks and impacts to the workforce associated with the petroleum activity are addressed in the corresponding Safety Case and are not discussed further in this document.

Additional sources of volatile organic compounds (VOC) emissions include condensate loading operations and fugitive emissions / general leaks.

Condensate loading operations, scheduled to occur once every two weeks, will initially result in emissions of inert gases (CO_2 and N_2) displaced from the condensate offtake tanker's inerted cargo storage tanks by the loaded condensate liquid and in the later stages of loading, emissions of volatile organic compounds (VOCs) evolving from the condensate itself and emitted via the tanker deck vent(s). Fugitive emissions from the FLNG are expected to be occasional only, minor in volumes and dispersed in location.

The pollutant concentrations for the steam boilers are summarised in Table 9-52 below.

Table 9-52: Measured Emission Rates for the HP Steam Boilers at FLNG

Combustion Source	Average Dry Standard Stack Flow Rate per boiler (Nm^3/min)	Average Measured during Sep 2019 Stack Test
Steam boilers A-40010 to A-40070 (running on fuel gas)	3,508	NOx – 147mg/Nm^3 SO_2 – 1.2 mg/Nm^3 PM – 3.3mg/Nm^3
Steam boilers A-40010 to A-40070 (running on diesel)	3,629	NOx – 269mg/Nm^3 SO_2 – 1.2mg/Nm^3 PM – 2.3mg/Nm^3

Whilst the boilers will be operational at all times when the facility is producing, the essential and emergency diesel generators will be used only in the event of planned and unplanned/ emergency non-routine operations and when tested as an integrity critical equipment. The volumes of flared gas will also fluctuate above the baseline flaring rates (i.e. pilot gas only) as a result of potential process upsets and plant shutdowns and restarts. Acid gas venting will occur continuously whilst producing; however the rates and composition of the gas may change depending on the feed gas composition.

A representative atmospheric pollutant and air pollutants inventory has been compiled using production and mass balance data for the highest expected production year and is presented in Table 9-53. Since emissions data has been estimated using a combination of vendor emission guarantees, where available and NPI and US EPA AP-42 emission factors, as well as assumptions about production rates and facility uptime for that year, the quoted numbers should be viewed as an order of magnitude estimate only.

Table 9-53: Prelude FLNG Atmospheric Emissions Inventory

			Emission Rates [tonnes/a]				
#	**Emission Source**	**Approx. Fuel Consumption Rate [tonnes/ annum]**	**NO_2**	**SO_2**	**CO**	**PM**	**VOC**
1	Steam Boilers (Fuel Gas)	200,000	594	4.0	182	14	8
2	Steam Boilers (Diesel)	50,000	281	1.2	78.9	2.4	1.8
3	Essential Diesel Generators	500	10	4.8	2.1	0.3	0.2
4	Flaring	600,000	900	0.0	5220	33.6	9000
5	Acid Gas Vent	1,000	0.0	0.0	0.0	0.0	20
6	Fugitive Emissions	100	0.0	0.0	0.0	0.0	100
7	Supply Vessel	300	50	0.7	3.9	1.5	1.4
8	Infield Support Vessel	4000	296	4.4	23	8.9	8.1
	TOTAL		**2130**	**15**	**5510**	**61**	**9139**

Notes: Boiler emissions were estimated based on the October 2019 Stack Testing Results. Other emission rates were based on NPI default values and design datasheets.

The inventory indicates that emissions from the Prelude FLNG are comparable in magnitude to emissions from other oil and gas facilities, specifically the INPEX Ichthys FPSO (Inpex Browse Ltd, 2008). Emissions from Prelude FLNG and the Ichthys FPSO and supporting marine vessels contribute to pollutant levels in the local marine environment airshed. The impacts of these combined emission sources on the air quality of the airshed has been examined in a screening air quality modelling study and is discussed in section 9.10.2 below.

9.10.2 Description and Evaluation of Impacts

Given the offshore remote context, environmental sensitivities that may be impacted by emissions of atmospheric pollutant include only the physical environment (air quality and visual amenity). No impacts on the socio-economic and cultural environment are reasonably foreseeable. Impacts on the physical environment can be summarised as:

- Planned emission of atmospheric pollutants to Prelude airshed under routine and non-routine (planned and emergency) operating conditions
- Routine and non-routine flaring resulting in smoky flare and impact on visual amenity.

Occupational health effects associated with emissions of air pollutants are excluded from the scope of the EP and covered in the Prelude Safety Case and supporting occupational health management program and procedures. These have been extensively modelled in the design phases of the Project and mitigated through design and operating procedures.

Physical Environment

Impacts on Air Quality

The Prelude Atmospheric Pollutant and Air Toxics Inventory indicates that the HP Steam Boilers emit >95% of the total Prelude PM emissions, approx. 80% of the NO_2 emissions and 44% of the CO emissions. The other significant source of these emissions includes the sum of all marine vessels operating within the field for materials delivery or product offtakes, however these emission sources are periodic and of short duration in nature and have therefore been excluded from the screening air quality modelling study (Shell PTS, 2016).

The study used the USA EPA AERSCREEN model, based on the Gaussian dispersion methodology and applied a conservative approach to overcome the constraints of the model, i.e.:

- Each emission source was modelled separately across the worst-case weather and wind combinations, whereupon the predicted ambient concentrations of pollutants were subsequently summed up to calculate the resultant ambient concentrations at the points of interest. Summation of predicted ambient concentrations implies that all pollutant molecules do not interact with any other gases in the atmosphere or dissolve in water, which is a conservative assumption.
- The worst-case weather conditions are effectively assumed to be present the entire time of the year, which is another conservatism built into the model.
- Emissions from the Ichthys FPSO, derived from the Ichthys Environmental Impact Statement (Inpex Browse Ltd, 2008), were also modelled and added to the predicted ambient ground level (in this context sea level) concentrations of pollutants from Prelude sources for the targeted points of interest.

Ground-level concentrations of pollutants were predicted at distances of 17km and 40km from the Prelude facility (points of interest), which represent the distances to the Ichthys FPSO, operated by INPEX and Browse Island (see Figure 9-18).

Predicted concentrations at these locations were compared to the Australian Ambient Air Quality Standards (National Environment Protection Council, 1998) which have been used as a proxy for the baseline air quality in the local airshed. In addition, these concentrations have also been compared to the proposed new ambient air quality standards for NO_2, SO_2 and $PM_{2.5}$ listed in the proposed NEPM Air Quality Measure Draft for Public Comment (National Environment Protection Council, 2019).

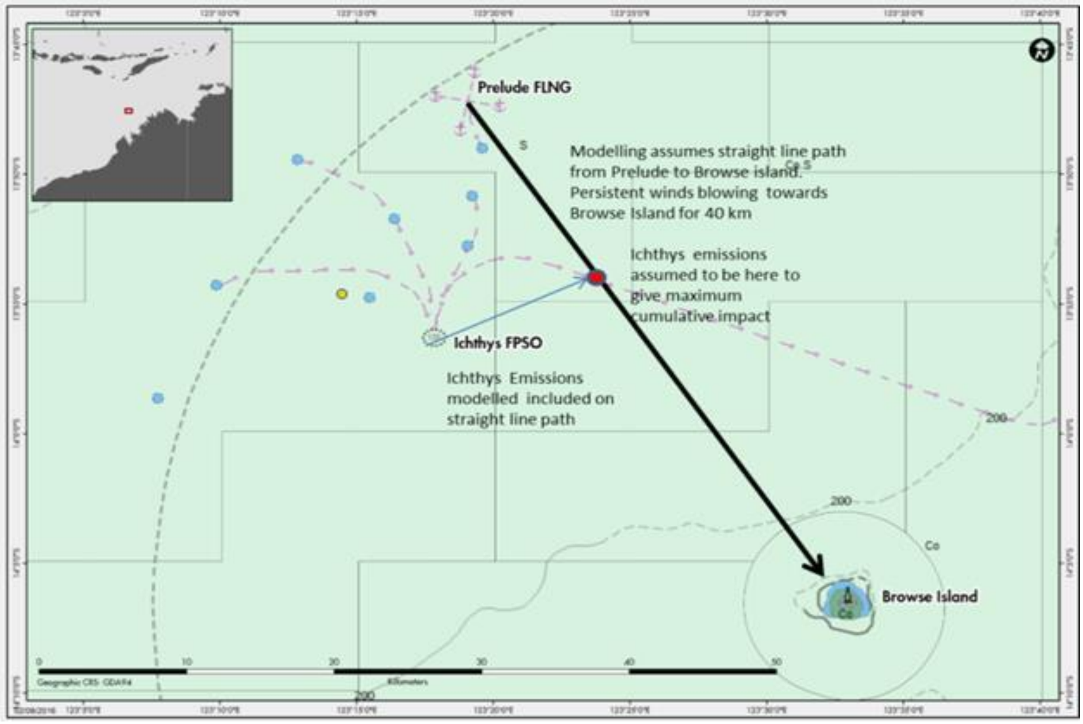

Figure 9-18: Area Map and Modelled Emission Locations

Three different operating scenarios were examined, i.e. Normal Operations, Exceptional Case and Worst Reasonable Exceptional Case. The Exceptional and Worst Reasonable Exceptional Cases represent the non-routine operations associated with commissioning, start-up and shut down conditions. In these exceptional circumstances, only the wet flare will be operational whilst the front end of the plant is stabilised and the LNG trains are started up. During normal operations, the plant is designed to run without any routine flaring of hydrocarbons, flares will be maintained lit only.

The three cases modelled are summarised below :

- Normal Operations Case:
  - 6 Boilers running on natural gas.
- Exceptional Case:
  - 3 Boilers running on diesel
  - 2 Essential Diesel Generators
  - Wet HP Flare: 30% of gas feed.
- Worst Reasonable Exceptional Case:
  - 5 Boilers running on diesel
  - 2 Essential Diesel Generators
  - Wet HP Flare: 50% of gas feed.

A summary of modelling inputs for the FLNG emissions is provided in Table 9-54.

Table 9-54: Prelude FLNG Air Modelling Inputs (on a per stack basis)

Source	Stack Height (m ASL)	Stack Diameter (m)	Exit Velocity (m/s)	Exhaust Temp (K)	Gross Heat Release Rate (10^6 cal/s)	NO_x (kg/hr)	SO_2 (kg/hr)	$PM_{2.5}$ (kg/hr)
Boilers NG	94	2.8	11.6	453	-	33	0(1)	6.8
Boilers Diesel	94	2.8	15.2	468	-	56	293(2)	12
Diesel Generators	94	1.0	35.6	638	-	22	12(2)	3.4
Wet HP Flare 30%	147	-	-	-	630	77	9.1	26(3)
Wet HP Flare 50%	147	-	-	-	1054	129	15	44(3)

(1) Sulfur content in fuel gas is 0 weight % (Shell Australia, 2018).

(2) conservatively based on 1.5% sulfur in diesel

(3) conservatively based on a slightly smoky flare

The modelling results for Normal Operations are summarised and compared to the current in force ambient air quality standards (National Environment Protection Council, 1998) in Table 9-55.

Table 9-55: Normal Operations Maximum Predicted Concentrations (comparison to current AAQS)

		FPSO (17km)			Browse Island (40km)			Current AAQS	
		(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)
NO_2	1hr	0.02	39	16%	0.008	16	7%	0.12	246
	Annual	0.002	3.9	6%	0.001	1.6	3%	0.03	62
$PM_{2.5}$	24hr	-	4.8	19%	-	2.0	8%	-	25
	Annual	-	0.8	10%	-	0.3	4%	-	8

Modelling results for Normal Operations indicate that under the worst-case weather and wind conditions, the ground-level concentrations of NO_2 and $PM_{2.5}$ at the points of interest in the Prelude airshed were predicted to be well below the current AAQS. These changes, though likely to have been overestimated, represent no substantial change to the ambient air quality in the airshed and are therefore considered to be associated with an acceptable level of environmental impact.

Modelling results for the Exceptional Case and Worst Reasonable Exceptional Case are summarised in Table 9-56 and Table 9-57. Only 1-hour and 24-hour concentrations were compared to the current air quality standards (National Environment Protection Council, 2019) due to the intermittent nature of these cases.

Table 9-56: Exceptional Case Maximum Predicted Concentrations (comparison to current AAQS)

		FPSO (17km)			Browse Island (40km)			Current AAQS	
		(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)
NO_2	1hr	0.02	49	19.9%	0.01	21	8.5%	0.12	246
SO_2	1hr	0.06	164	28.7%	0.02	69	12%	0.2	571
	24hr	0.03	99	43%	0.02	42	18.4%	0.08	228
$PM_{2.5}$	24hr	-	6.5	26%	-	2.9	11.6%	-	25

Table 9-57: Worst Reasonable Exceptional Case Maximum Predicted Concentrations (comparison to current AAQS)

		FPSO (17km)			Browse Island (40km)			Current AAQS	
		(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)	% of AAQS	(ppm)	(ug/m3)
NO_2	1hr	0.03	71	28.8%	0.02	31	12.6%	0.12	246
SO_2	1hr	0.09	270	47.3%	0.04	114	19.9%	0.2	571
	24hr	0.06	162	71%	0.02	68	29.8%	0.08	228
$PM_{2.5}$	24hr	-	9.5	38%	-	4.3	17.2%	-	25

The Exceptional Case and Worst Reasonable Exceptional Case maximum predicted pollutant concentrations are well under the current ambient air quality standards and as such are not expected to result in significant impacts to air quality within the airshed.

Impacts on Visual Amenity (Smoky Flare)

A flare steam injection system is designed and installed on Prelude FLNG. Steam is provided to the high pressure dry and wet flares and the low pressure wet flare to primiarly cool the flare tips and prevent thermal cracking.

Operational experience and vendor data indicate that at the highest flare combustion efficiency (lowest formation of VOC and particulate), the flare is still not completely smokeless. Additional steam injection can result in a smokeless but less efficient flare thus emitting more uncombusted fuel gas as well as additional GHG emissions from the process of producing more steam.

Apart from the aesthetic impact associated with a slightly smoky flare, there would be no material environmental impacts to local and regional airshed quality. In terms of health impacts, a Flare Flame-Out and Venting Atmospheric Dispersion Study (Shell Australia, 2013) was carried out to assess the extent of hazards associated with gas dispersion with regards to flammable and toxic risks from the flare and vent sources. The study confirmed that the vents and flares height and position were located at a safe distance to work places and the accommodation block to avoid any flammable, acute toxic or chronic exposure impacts at the facility.

9.10.3 Impact Assessment Summary

Table 9-58: Atmospheric Pollutant and Air Toxics Emissions Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence
Evaluation – Planned Impacts			
Physical Environment (Impacts on Air Quality)	-1	M	Slight
Physical Environment (Impacts on Visual Amenity)	-1	M	Slight
Biological Environment	N/A	N/A	N/A
Socio-Economic Environment	N/A	N/A	N/A

9.10.4 ALARP Assessment and Environmental Performance Standards

Table 9-59: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Use of renewable energy (e.g. solar, wind and wave) in lieu of fossil fuels for power generation and marine vessel propulsion	No	Use of solar, wind or wave energy for a continuously running operation does not have the required reliability and will also require additional space and capital investment which are not justified. Use of renewable technology for a complete offshore LNG processing facility is not available or technologically proven yet.	N/A	N/A	N/A
Elimination	No flaring of hydrocarbons	No	The flare system is a safety and loss prevention system and is required for the safe disposal of hydrocarbons in the event of process upsets or emergency situations. Flaring of hydrocarbon reduces the GHG emissions in comparison to these gases being vented.	N/A	N/A	N/A
Elimination	Recover the VOC emissions displaced during condensate loading and reuse in the process.	No	VOC emissions during condensate loading cannot be eliminated as this would require an additional complex installation to separate hydrocarbons from inert gas, possibly liquefy them and compress them to reuse in the process. This would lead to additional space requirements at the facility, congestion and sources of fugitive emissions for an infrequent operation (condensate loading occurs once in a fortnight). This option is not deemed to be ALARP.	N/A	N/A	N/A
Substitution	Use of electric motor drivers or aero-derivative gas turbines	No	Early design considered use of variable electric motor drivers of 80MW each, with the power demand of 200MW provided by a bank of aero derivative gas turbo-alternators, which are more efficient than a steam boiler solution. Steam for process use was to be generated by Waste Heat	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			Recovery Units (WHRU) in the Gas Turbine (GT) exhaust stacks. This arrangement was not found to be sufficiently electrically stable, particularly in upset and start-up conditions. Lack of stability would result in lost production and extended flaring leading to more atmospheric pollutant and GHG emissions, thereby negating the energy efficiency benefits achieved through the application of gas turbines. Direct drive aero derivative gas turbines were also considered to improve fuel efficiency by about 25% over the use of steam boilers, however the design was not mature enough to be adopted for the Prelude FLNG. Steam turbines were the option selected. Seven steam boilers generate sufficient steam to drive the main compressors and supply 120MW. This is less energy efficient than the other two options, resulting in an 8% fuel use increase, but is a more robust and reliable design in terms of equipment reliability. The boilers efficiency is anticipated to be greater than 90%.			
Engineering	The boilers are designed to IFC Guidelines for Thermal Power; the essential generators to IFC General EHS Guidelines; and the emergency generators to MARPOL 73/78 Annex VI.	Yes	Adoption of good industry practice available at the time Prelude FLNG was designed and constructed.	N/A	N/A - The design features were selected, installed and commissioned prior to the commencement of this EP, and are therefore not described in further detail here as an EPS.	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	HP Steam boilers designed as dual fuel and will be operated on fuel gas during steady state production operations	Yes	Fuel gas, produced at Prelude, is a cleaner burning fuel in comparison to diesel and will be preferentially used during normal operations. Diesel use will be required only during occasional shutdown and start-up scenarios.	N/A	N/A - The design features were selected, installed and commissioned prior to the commencement of this EP, and are therefore not described in further detail here as an EPS.	N/A
Engineering	Use of end of stack technology (e.g. scrubbers or filters) to clean the exhaust gas of nitrogen oxides or particulate matter.	No	End of stack technology is not an efficient way to minimise emissions due to additional material and labour requirements to maintain scrubbers or filters in working condition. Additional safety and operability hazards and generation of solid waste could outweigh the benefits of this technology. Furthermore, modelling of a number of scenarios indicated that air quality from releases of exhaust gas will not exceed the AAQA criteria at the nearest receptors.	N/A	N/A	N/A
Engineering	Inject steam into the flare system in order to reduce smoky appearance.	No	A flare steam injection system is designed and installed on Prelude FLNG. Steam is provided to the high pressure dry and wet flares and the low pressure wet flare to primiarly cool the flare tips and prevent thermal cracking. Operational experience and vendor data indicate that at the highest flare combustion efficiency (lowest formation of VOC and particulate), the flare is still not completely smokeless. Additional steam injection can result in a smokeless but less efficient flare, thus emitting more uncombusted fuel gas as	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			well as additional GHG emissions from the process of producing more steam.			
Engineering	Flaring or incineration of the acid gas stream to oxidise H2S and the residual hydrocarbons in the gas including methane and BTEX.	No	As the acid gas stream consists of more than 98% CO_2, to oxidise and render the hazardous components of the stream (i.e. H_2S, BTEX, PAH and CH_4) non-hazardous, it will be required to enrich the acid gas with large volumes of hydrocarbons in order to raise the calorific value of the gas and burn it. This will lead to emissions of other pollutants (NOx, SOx, PM, CO) and more GHG emissions to atmosphere and the installation of a more complex system to operate on the facility in comparison to a vent stack.	N/A	N/A	N/A
Administrative and Procedural Controls	Implement an adaptive stack emissions monitoring program (Section 8.11.5)	Yes	A stack emissions monitoring program will be implemented to validate pollutant emission rates for the boilers. The results of the program will be used to decide on the need of additional monitoring scope and frequency (adaptive management approach) and whether additional modelling studies are required.	8.1	Representative boiler stack samples carried out at least once and an assessment made on adaptive management controls.	Stack testing reports and assessment
Administrative and Procedural Controls	Implement a boiler surveillance program to ensure boilers are operating within the design operating envelope.	Yes	Operating the boiler system within the design operating envelope and at the targeted/design efficiency provides a degree of assurance that the emission levels are within the levels guaranteed by the vendor of the equipment. Parameters monitored includes: • Type of fuel used • Quantity of fuel used • Air flow (or fan speed) • Process temperature • Process oxygen content	8.2	A surveillance program is in place for the boilers and power generation units to ensure that they are operating within the design operating envelope.	Trends/data showing operation within operating envelope.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Use low sulphur fuel oil/ diesel (< 0.5% m/m S) for boilers and marine support vessels supporting operations	Yes	This MARPOL Annex VI requirement, enforced by AMSA Marine Order 97, comes in force from 1 January 2020 and will apply to all marine vessels operating in the field including offtake tankers. This requirement will also be adopted for FLNG.	8.3	Use only low sulphur fuel oil/ diesel (<0.5% m/m S) for FLNG and marine support vessels.	Sulphur content of diesel, % w/w as verified in bunker receipts delivered to the FLNG on loading and bunker receipts for marine support vessels
Administrative and Procedural Controls	Specified marine vessels supporting Prelude operations comply with AMSA Marine Order 97 (Marine Pollution Prevention – Air Pollution) and the requirements of the Shell Marine Assurance Process and procedures regarding management of air pollution	Yes	AMSA Marine Order 97 requires specified marine vessels to possess the applicable pollution prevention and energy efficiency certificates. These certificates include Engine International Air Pollution Prevention Certificate (EIAPP), International Air Pollution Prevention Certificate (IAPP) and an International Energy Efficiency (IEE) Certificate. In addition all vessels with a gross tonnage of 400 or more are required to carry a Ship Energy Efficiency Management Plan (SEEMP). These requirements are also recognised and enforced in the Shell Marine Assurance Process and procedures.	8.4	Specified vessels are required to have the following valid documentation as required by class: • EIAPP certificate; • IAPP certificate; • IEE certificate; and • SEEMP.	Assurance records confirming SEEMP and IAPP, EIAPP, IEE certificates are in place for specified vessels.

9.10.5 Adaptive Stack Monitoring Program

The intent of the adaptive stack monitoring program for the Prelude steam boilers is to verify that ‘end of pipe’ pollutant emission rates comply with the design emission rates for the boilers, specified in Table 9-52. These design emission rates have been used in the screening air quality modelling, discussed in Section 9.10.2, which provides the scientific basis to judge on the acceptability of Prelude operations impact on ambient air quality.

The two decision points that inform the planned stack monitoring program are the compliance to the design emission rates for the boilers and the compliance to the impact acceptance criterion specified in Section 9.10.6 below. Responses to these questions will inform the adaptive actions as per Figure 9-19 below.

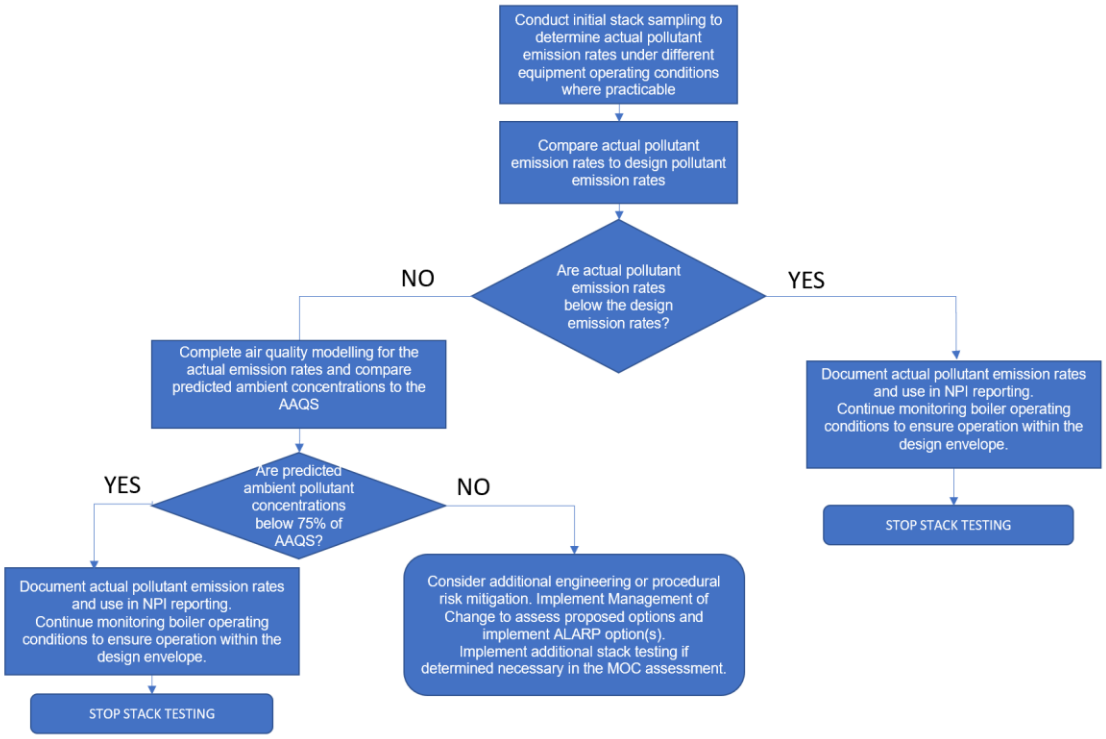

Figure 9-19: Flowchart: Adaptive Response Stack Testing Program

9.10.6 Acceptability of Impacts

Table 9-60: Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	Air Quality	No significant impacts to air quality defined as no substantial change in air quality which may adversely impact on biodiversity, ecological	Yes	Screening air quality assessment indicates that predicted ground level concentrations of pollutants at the closest sensitive receptors for the worst-case modelling conditions are below

		integrity, social amenity or human health.		75% of the current NEPM ambient air quality standards. The worst-case wind conditions associated with highest predicted ground level ambient pollutant concentrations at the closest sensitive receptors (which are well below 75% of the current ambient air quality standards) persist only 1% of the time.
Biological Environment	N/A	N/A	N/A	N/A
Socio-economic and Cultural Environment	N/A	N/A	N/A	N/A

The assessment of atmospheric pollutant emissions determined the impact magnitude to be minor. Given that air quality in the area is generally expected to be very high and the lack of sensitive human receptor populations in the Prelude airshed as defined in the Air Quality NEPM (NEPC, 1998), the residual impact consequence ranking is assessed as Slight (Magnitude -1, Sensitivy – M) and therefore acceptable (Table 9-58). Impacts on air quality have also been considered in the following context.

Principles of ESD

The impacts from atmospheric pollutant and air toxics emissions are acceptable and consistent with the principles of ESD based on the following points:

- The environmental values/sensitivities within the Operational Area and the regional airshed are not expected to be significantly impacted.
- The precautionary principle has been applied to the impact modelling study and in the impact assessment.

Relevant Requirements

Management of impacts from atmospheric emissions is consistent with relevant legislative requirements, including:

- Air quality in the Prelude regional airshed complies with the current NEPM Ambient Air Quality Standards (National Environment Protection Council, 1998) as well as with the proposed draft NEPM Ambient Air Quality Standard (National Environment Protection Council, 2019).
- Marine fuel oil used by HP Steam Boilers and marine vessels supporting operations complies with 1 January 2020 MARPOL Annex VI requirement for 0.5% m/m S content in marine fuel oil and diesel.

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of atmospheric pollutant emissions from the Prelude FLNG facility and supporting marine operations indicates significant impacts and risks to threatened and migratory species will not credibly result from combustion of fuels, flaring, acid gas and VOC venting and fugitive emissions aspects of the Prelude petroleum activities.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-61.

Commonwealth Marine Environment

The impacts and risks from atmospheric pollutant emissions from the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 9-61.

Table 9-61: Summary of Alignment of the Impacts from the Atmospheric Pollutant Emissions Aspect of the Prelude petroleum activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	None applicable to atmospheric pollutant emissions	N/A
Wetlands of International Importance	None applicable to atmospheric pollutant emissions	N/A
Commonwealth marine area	No significant impacts on Air Quality	Criteria for significant impacts and risks to air quality over the Commonwealth Marine area where the Prelude project will operate have not been triggered by atmospheric pollutant emissions from the Prelude field.

External Context

There have been no objections or claims raised by Relevant Persons in preparation of this EP related to atmospheric pollutant and air toxics emissions aspect.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with Shell's internal requirements.

Acceptability Summary

The assessment of impacts from atmospheric pollutant and air toxics emissions determined the residual impact rankings to be Slight (Table 9-4). As outlined above, the acceptability of the impacts and risks from this aspect have been considered in the context of:

- The established acceptability criteria for impacts and risks for this aspect
- ESD

- Relevant legislative requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual impacts are slight which Shell considers to be inherently acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the atmospheric pollutant emissions aspect.

Based on the points discussed above, Shell considers the impacts from atmospheric pollutant emissions associated with Prelude operations to be acceptable and ALARP.

9.10.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
Predicted ground level concentrations of atmospheric pollutants are below 75% of the applicable ambient air quality criteria[8]	Steam boilers adaptive stack emissions monitoring (validation of vendor design emission rates). Atmospheric pollutant and air toxics emissions inventory (as part of NPI report).

9.11 Greenhouse Gas Emissions

9.11.1 Aspect Context

Operating the Prelude FLNG facility and producing LNG, LPG and condensate results in Greenhouse Gas (GHG) emissions from various sources such as:

- Combustion of gas for power generation
- Flaring of hydrocarbon for process safety purposes
- Venting of reservoir CO_2.
- Fugitive emissions / General Leaks

[8] The 75% of AAQS acceptance criterion for level of impact for ambient air quality has been derived from the National Environment Protection Council (Ambient Air Quality) Measure, Technical Paper No. 4, Screening Procedures (National Environment Protection Council, 2007). This paper provides screening criteria against which jurisdictions can assess the monitoring needs of their regions where reduced or no direct monitoring is justified in accordance with clause Clause 14 (3) of the Ambient Air Quality NEPM: "Fewer performance monitoring stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure." The NEPM Peer Review Committee (PRC) recommended using 75% of the AAQS criteria as the maximum acceptance limit for any ambient air pollutant screening method (e.g. inventory, modelling or monitoring), below which no air quality monitoring, or no additional air quality monitoring stations need to be established. It is further recommending lower and specific to each pollutant thereshold levels when taking into account the difference in screening methods, their reliability and the exposed populations. The threshold level of 75% of the AAQS is considered appropriate for an acceptable level of impact when assessing air emissions from the Prelude field as no sensitive receptors as defined in the Ambient Air Quality NEPM are present in the Pelude airshed.

- Combustion from transportation – e.g. vessels supporting the FLNG operations

The above sources are further discussed in detail in Section 9.10.1.

GHG Emissions Inventory

GHG emissions forecasting for Shell is part of the annual operations planning process. Production, energy consumption and GHG emissions forecasts are also required to be submitted to the Commonwealth Government's Clean Energy Regulator under the *National Greenhouse and Energy Reporting Act 2007* (NGER Act) Safeguard Mechanism.

The Safeguard Mechanism sets out the compliance requirements for the reporting and management of Prelude FLNG's GHG emissions. Prelude FLNG has an initial calculated baseline which will be replaced with a production-adjusted baseline over time in accordance with the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015. Emissions above the baseline will be subject to compliance obligations, as called for in the NGER Act.

GHG emissions forecasts are conducted on an annual basis, the latest forecast at the time of this EP was completed during the Q4 2019 Business Planning cycle and is summarised in Table 9-62 below.

Table 9-62: Prelude FLNG Estimated Annual GHG emissions (estimated in Q4 2019)

Type	Estimated Emissions (CO_2e kTonnes/year)				
	2020	2021	2022	2023	2024
Reservoir CO_2	700	800	1,100	1,000	1,000
Fuel combustion	1,500	1,400	1,700	1,700	1,600
Flaring	500	400	300	300	300
Fugitive	<50	<50	<50	<50	<50
Total	2,700	2,600	3,100	3,000	2,900

The GHG inventory for the highest production throughput year during the first five year period indicates that 97% of all GHG emissions will be associated with fuel combustion and reservoir CO_2 venting. Flaring and fugitive emissions constitute less than 3% of the total. These results indicate that the GHG emissions associated with Prelude operations will depend primarily on the CO_2 content of the reservoir (Figure 9-20).

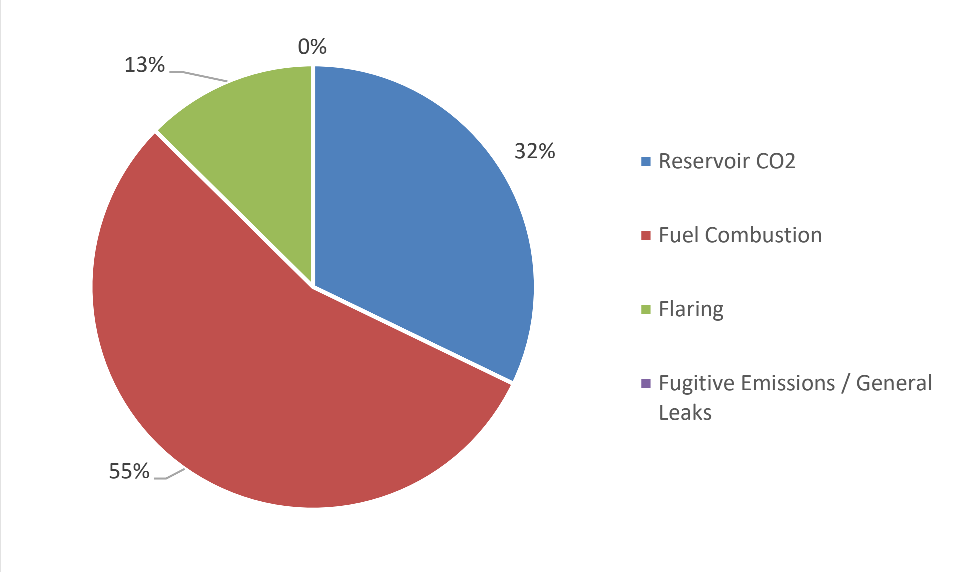

Figure 9-20: Prelude FLNG Estimated Annual GHG emissions

9.11.2 Description and Evaluation of Impacts

Anthropogenic emissions of GHGs to the Earth's atmosphere have been recognised by reputable scientific bodies, international organisations and governments around the world as the single most important factor leading to accelerated climate change and global warming, which trends and effects have been closely monitored since the second half of the last century.

Environmental impacts from global warming and climate change act on a global scale in which the magnitude of Prelude's contribution is impossible to determine in isolation.

It is therefore considered that the application of Shell's environmental impact and risk assessment process (Sections 9.1 to 9.2) to assess GHG emissions from the Prelude related petroleum activities is not appropriate. The acceptability of impacts from the Prelude GHG emissions should instead be considered in the context of benchmarking its GHG efficiency, and continued efforts to minimise GHG emissions from the facility over its production life.

Benchmark Comparisons

Prelude has benchmarked its GHG emissions performance to determine how it ranks amongst other Australian LNG facilities.

Figure 9-21 shows the benchmarking of the Prelude GHG emissions per tonne of product against publicly available data for other global LNG projects.

Emissions are broken down into those from fuel combustion and flaring; emissions from the upstream component and as a separate variable, emissions from the CO_2 content in the reservoir. Separating out the reservoir CO_2 (acid gas venting) allows to benchmark the GHG efficiency of the production process based on the selected technology alone, thus eliminating the significant variability, which the reservoir CO_2 content brings to the GHG emissions total and GHG emissions intensity for each facility.

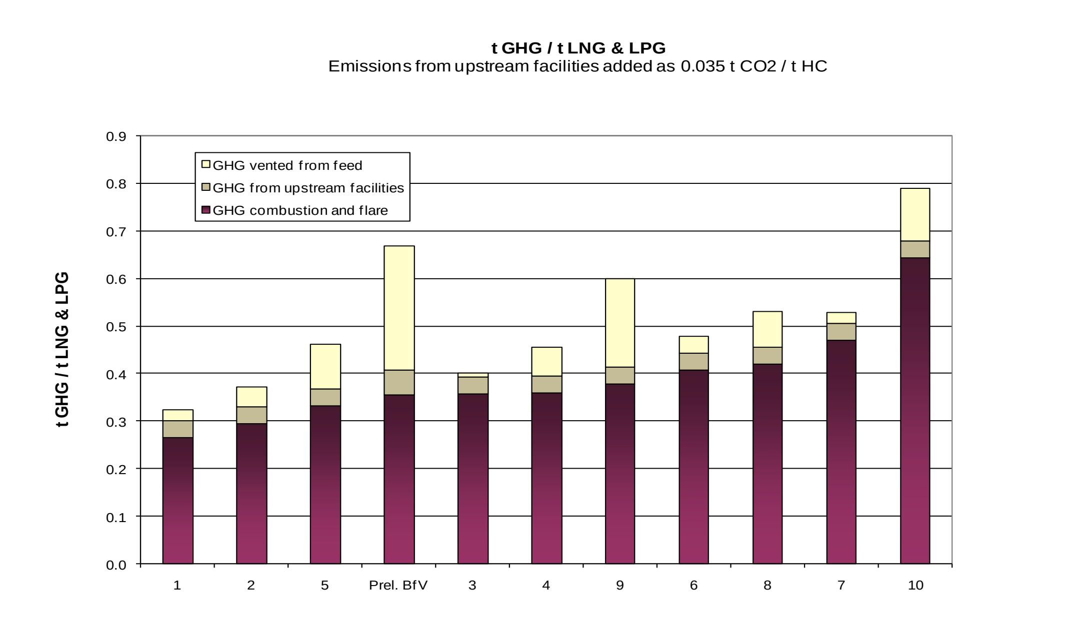

Figure 9-21: LNG Plant GHG benchmarking

Figure 9-21 indicates that the Prelude GHG emissions originating from fuel gas consumption and flaring rank the Prelude FLNG as the fourth most efficient facility in its peer group. When the acid gas venting contribution is considered, Prelude's GHG emission intensity results in the facility dropping down in rank as second last in terms of efficiency at ~0.7 tonne CO_2e / tonne product. Note that GHG efficiency is likely to reduce in later field life.

Prelude's GHG performance has also been benchmarked using data on other Australian facilities, extracted from publicly available information. Compared to other LNG projects in the Browse region with similar high CO_2 contents in their feed gas, the Prelude FLNG project has a lower overall GHG intensity, mainly due to its considerably lower upstream GHG emissions.

The lower upstream GHG emissions intensity could be primarily attributed to the following Prelude development decisions:

- Locating the FLNG over the gas field has negated the need for a long pipeline to shore and has reduced compression requirements during the later life of the field as the reservoir pressure declines.
- Integrating product offloading facilities into the design of the FLNG reduces gas compression requirements for gas export to an onshore terminal.

The key features of the Prelude FLNG production technology contributing to the improvement of GHG intensity performance include:

- Shell's proprietary Double Mixed Refrigerant (DMR) process uses mixed refrigerant for the pre-cooling and liquefaction cycles which allows for a flexible process to enable full power utilisation over a wide range of ambient temperatures. The composition of the pre-cool refrigerant can be modified to balance ambient temperature changes and cut-point temperatures where traditional C3-MR processes cannot be adjusted in this way. Using another option was Nitrogen Cycle which is inherently safer, but DMR has better liquefaction efficiency. Nitrogen Cycle can use almost double the amount of compression power to make LNG compared to DMR technology. DMR technology means there is less fuel gas demand and lower GHG emissions.

- Shell's 3-stage DMR process technology rather than a 2-stage DMR process increases the liquefaction efficiency by 8% at the expense of additional equipment required for a 3rd stage. Potentially more LNG can be produced using the same amount of power and fuel gas which translates to the same GHG emissions for 8% more production.
- Prelude FLNG was able to increase efficiency in production by reducing cooling water temperatures (i.e. taking colder seawater from a depth of 150 m rather than taking seawater from surface). At this depth, the sea water supply is nearly constant at a temperature of 21-22°C. For every degree that the temperature of the cooling medium is colder, 0.6-0.7% of production is gained for the same energy cost.

9.11.3 Impact Assessment Summary

As discussed in the previous section, a qualitative or quantitative assessment of the Prelude contribution to the global impact of global warming cannot be reasonably carried out within the existing impact assessment process framework (see Sections 9.1 to 9.2). Instead, the measures applied to managing GHG emissions have been examined to determine if they are ALARP.

9.11.4 ALARP Assessment and Environmental Performance Standards

Table 9-63: ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	Use of renewable energy (e.g. solar, wind and wave) in lieu of fossil fuels for power generation and marine vessel propulsion	No	Use of solar, wind or wave energy for a continuously running operation does not have the required reliability and will also require additional space and capital investment which are not currently justified. Use of renewable technology for a complete offshore LNG processing facility is not available or technologically proven yet.	N/A	N/A	N/A
Elimination	No flaring of hydrocarbons	No	The flare system is a safety and loss prevention system and is required for the safe disposal of hydrocarbons in the event of process upsets or emergency situations. Flaring of hydrocarbon reduces the GHG emissions in comparison to these gases being vented.	N/A	N/A	N/A
Elimination	Reinject the acid gas into an appropriate geological formation	No	Based on a comprehensive assessment, no technical and/or economically viable solution was identified for re-injection due to: • Lack of a contained and confined geological formation to effectively contain and seal the injected acid gas stream. Recirculation of the CO_2 through leakage back into production fluids leading to material compatibility issues was found to be a possible outcome of reinjection in the available geological strata. • Re-injection would have resulted in extra equipment onboard the FLNG Facility (CO2 compression, dehydration, extra	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			steam boiler), leading to additional sources of safety risk, emissions, congestion and maintenance requirements. CO2 re-injection would also have required a considerable monitoring (including 4D seismic) and reporting effort to comply with Government legislation on carbon capture and storage, which could have introduced a new range of environmental, safety and operability hazards.			
Substitution	Use of electric motor drivers or aero-derivative gas turbines	No	Early design considered use of variable electric motor drivers of 80MW each, with the power demand of 200MW provided by a bank of aero derivative gas turbo-alternators, which are more efficient than a steam boiler solution. Steam for process use was to be generated by Waste Heat Recovery Units (WHRU) in the Gas Turbine (GT) exhaust stacks. This arrangement was not found to be sufficiently electrically stable, particularly in upset and start-up conditions. Lack of stability would result in lost production and extended flaring leading to more atmospheric pollutant and GHG emissions, thereby negating the energy efficiency benefits achieved through the application of gas turbines. Direct drive aero derivative gas turbines were also considered to improve fuel efficiency by about 25% over the use of steam boilers,	N/A	N/A	N/A

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			however the design was not mature enough to be adopted for the Prelude FLNG. Steam turbines were the option selected. Seven steam boilers generate sufficient steam to drive the main compressors and supply 120MW. This is less energy efficient than the other two options, resulting in an increase in fuel use, but is a more robust and reliable design in terms of equipment reliability.			
Engineering	Use of Shell's proprietary Double Mixed Refrigerant (DMR) process in three stages	Yes	Shell's proprietary Double Mixed Refrigerant (DMR) process uses mixed refrigerant for pre-cooling and liquefaction cycles which allows for a flexible process to enable full power utilisation over a wide range of ambient temperatures. Shell's 3-stage DMR process technology increases the liquefaction efficiency by 8% whilst using the same amount of power and fuel gas.	N/A	N/A - The design features of the DMR process were selected, installed and commissioned at the time this EP commences, and are therefore not described in further detail here as an EPS.	N/A
Engineering	Supply of colder seawater from 150m water and use as a cooling medium for main process	Yes	At a depth of 150 m, the sea water supply is nearly constant at a temperature of 21-22°C. For every degree that the temperature of the cooling medium is colder, 0.6-0.7% of production is gained for the same energy cost. Taking this quantity of seawater 150m below surface rather than at surface is novel for FLNG from a design, construction and installation perspective.	N/A	N/A - The design features of the CW system were selected, installed and commissioned at the time this EP commences, and are therefore not described in further detail here as an EPS.	N/A
Administrative and Procedural Controls	Prelude Operations Playbook provides fuel model guidance to minimise GHG emissions during	Yes	Prelude's Operations Playbook aims to achieve an optimised process shutdown and start up sequence to minimise process upsets	9.1	The Prelude Operations Playbook is available and provides panel operators the recommended optimum fuel	Prelude Operations Playbook

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
	planned plant shutdowns and start-ups.		and reduce loss of hydrocarbon inventory to flare and acid gas venting.		mode during planned plant shutdowns and start-ups to achieve GHG reduction.	
Administrative and Procedural Controls	Conduct an annual forecast of future GHG emissions from Prelude FLNG	Yes	An annual GHG emissions forecast is conducted as part of business planning in order to determine anticipated performance levels, set internal targets and determine whether any GHG abatement projects are required.	9.2	Conduct an annual forecast of future GHG emissions from Prelude FLNG	Annual GHG Emissions Forecast
Administrative and Procedural Controls	Report annually the calculated GHG Emissions and Energy to the Clean Energy Regulator.	Yes	This is a regulatory requirement under the National Greenhouse and Energy Reporting Act 2007 (NGER Act 2007). Because NGER reporting is a regulatory requirement, no EPS has been developed for this requirement.	9.3	N/A	N/A
Administrative and Procedural Controls	Fugitive Emissions Surveys	Yes	Implement a risk-based Leak Detection and Repair program on Prelude FLNG which includes routine surveys to identify fugitive emissions and prioritise the repair. Minimisation of fugitive emissions / general leaks reduces the risks of unsafe situations as well as GHG emissions.	9.4	Undertake targeted topside fugitive emissions / general leaks survey on an annual basis.	Records of leak detection and repair survey
Administrative and Procedural Controls	GHG and Energy Management System	Yes	Example of a GHG and Energy Management System is CEMIS which is a three tier (plant, unit and equipment level) operational performance system which provides a “live” monitoring of plant, unit and equipment performance. This system will allow for discreet actions to be undertaken at equipment or unit level to maintain optimise the plant operational and GHG emissions performance. Specified plant includes:	9.5	Commence monitoring plant energy performance within 18 months of completion of all relevant performance tests for specified plant equipment	GHG and Energy monitoring Key Performance Indicator (KPI) trends

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
			- AGRU - NGL Extraction and Liquefaction - Steam and Power - Flaring and Venting			

9.11.5 Acceptability of Impacts

Acceptability of Prelude's GHG emissions impacts has been discussed in terms of benchmarking of the key GHG performance indicators and the control measures that have been implemented and will continue to be applied in the management of GHG emissions from the asset.

It is difficult to assess the impact of Prelude GHG emissions in isolation as the effects of global warming and associated climate change are the cumulative effect of many sources, across the globe, and it is the cumulative effects that ultimately bring about climate change. While Prelude GHG emissions contribute on a cumulative basis to a changing global climate, it is considered not credible that GHG emissions will have any direct negative environmental impact on receptors, including matters of NES, in the Browse basin area.

Also, Prelude FLNG GHG emissions intensity, when compared with like for like extraction and use of other fossil fuels (e.g. coal) on a well to final consumer basis, could potentially have a net positive impact.

GHG emissions management was considered at all stages of the project, from concept through design and development to reduce the GHG emissions from the FLNG facility during operations. Best practices have been adopted and employed through the engineering design of the project to, wherever economically viable, reduce GHG emissions. Ongoing GHG management measures will also include live monitoring of the plant performance in terms of its thermal efficiency, GHG intensity and fuel use, allowing incremental improvements to the plant's GHG performance to be undertaken when safe and practicable.

Principles of ESD

Management of GHG emissions from Prelude operations is consistent with the principles of ESD based on the following points:

- The decision-making process on production technology has effectively integrated both long-term and short-term economic, environmental, social and equitable considerations.

This has been completed through inclusion of GHG minimisation and energy efficiency as technology selection criteria along with other technical and monetary considerations in design as well as with the long term plans for managing the GHG emissions and energy intensity of the Prelude production process (as demonstrated in the ALARP assessment table).

Relevant Requirements

Management of GHG emissions on Prelude FLNG will be consistent with Australia's energy and GHG legislation, including the National Greenhouse and Energy Reporting Act 2007 (as amended) and its regulations as follows:

- the National Greenhouse and Energy Reporting Regulations 2008 (as amended)
- the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (as amended) sets out the details that establish compliance rules and procedures for administering the safeguard mechanism.

External Context

In addition to regulatory requirements, there have been no objections or claims raised by Relevant Persons in preparation of the EP related to GHG emissions or energy intensity aspect of Prelude's FLNG operations.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with Shell's internal requirements.

Acceptability Summary

Based on benchmarking data, meeting relevant regulatory requirements such as NGERS and the SGM and adoption of good industry practice to reduce the GHG emissions associated with Prelude operations to ALARP, Shell considers risks and impacts from GHG emissions to be acceptable.

9.11.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
GHG emissions associated with the Prelude asset will be consistent with national and international mechanisms for the management of GHG emissions as regulated by the Clean Energy Regulator.	No non-compliance notices from the Clean Energy Regulator

9.12 Waste Management

9.12.1 Aspect Context

Many activities on the FLNG and supporting vessels results in the generation of a variety of hazardous and non-hazardous waste streams. Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard and scrap steel. Hazardous wastes include oil contaminated materials (e.g. sorbents, filters and rags), spent chemical containers, aerosol containers, light tubes and batteries. Sand and sludges may also be generated during well clean-up operations and process vessel maintenance. All wastes generated (other than permitted waste discharge streams addressed elsewhere within this EP) are transported to shore for reuse, recycling, treatment or disposal by a licensed waste contractor. Note that any waste management and disposal within international jurisdictions is out of scope of this EP.

The management of wastes will not result in any planned impacts to the offshore marine environment given there is no planned release; however, improper storage and handling of wastes may result in accidental losses to the marine environment. These unplanned events may result in impacts to the marine environment. Shell's extensive operational experience indicates most accidental releases of wastes to the marine environment are typically relatively small scale and infrequent events.

Low level Naturally Occurring Radioactive Materials (NORMs) may also occur in sludges, scale and sands typically associated with the inlet/separator facilities, filters and low points within the hydrocarbon processing system. The NORM nuclides of primary concern in oil and gas production are Radium-226 and Radium-228. These decay into various radioactive progeny, before becoming stable. Radium-226 and Radium-228 belong to the two principal radioactive decay series associated with NORMs in the oil and gas industry (Uranium-238 and Thorium-228 respectively)

(APPEA 2002 and IOGP 2008). Such waste streams are removed from the facility for appropriate treatment/disposal onshore.

During process related maintenance activities and opening of vessels, potentially mercury-contaminated sludges and sands may also be recovered. As with other hazardous wastes, these will be assessed, handled and stored appropriately and sent to shore for proper disposal.

Waste segregation is established and maintained through the provision of labelled bins, skips or other appropriate receptacles used to comingle similar waste streams in accordance with their classification to realise efficiencies in storage, transport, treatment, recycling and/or disposal.

There are a number of dedicated and secondary/contingency waste storage areas on the FLNG facility to ensure there is sufficient capacity for all anticipated activities and phases of the activity. Waste storage on the FLNG facility has a capacity to accommodate approximately 14 days of waste accumulation during normal operations. Waste storage areas are described further in the Prelude FLNG Waste Management Procedure (HSE_PRE_010753). Additional temporary laydown areas for waste storage may be established during specific campaigns as required, e.g. during major maintenance. Waste receptacles are back loaded onto supply vessels via crane for transportation to onshore facilities.

9.12.2 Description and Evaluation of Impacts and Risks

Physical Environment

Improper management of hazardous or non-hazardous wastes and/or accidental release may result in pollution of and contamination in the marine environment via reduction in water and sediment quality. This may result in toxic effects, however given the dynamic nature of the offshore receiving environment and the small nature and scale of most potential waste spills/releases, any such effects will be of short duration and highly localised. The implications to potentially sensitive receptors due to a reduction in water and sediment quality are discussed further in the Biological Environment assessment below and are not assessed further in the context of the physical environment.

Biological Environment

There is the potential for impacts on marine fauna that may interact with wastes, such as packaging and binding, should these enter the ocean as marine fauna can become entangled and waste plastics can be ingested when mistaken as prey (Ryan et al. 1988). Marine debris has been identified as a threat for a range of vertebrate fauna species, including marine turtles, birds, marine mammals and sharks and rays. Marine debris is listed as a key threatening process under the EPBC Act. Persistent wastes such as plastics are of particular concern, as the threat to fauna may remain long after the waste is released. Potential impacts of marine debris on key fauna species include (DEWHA 2009c):

- Entanglement, potentially resulting in restricted mobility, drowning, starvation, smothering and wounding
- Ingestion (particularly of plastics) leading to physical blockage of digestive systems, leading to starvation
- Acute or chronic toxic effects.

Plastic debris can also act as a concentrator of Persistent Organic Pollutants (POPs) that occur universally in seawater at very low concentrations as they get picked up by meso/microplastics via partitioning. The hydrophobicity of POPs can facilitate concentration in the meso/microplastic litter at a level that is several orders of magnitude higher than that in seawater. When ingested by marine species, contaminated plastics present a credible route by which the POPs can enter the marine food web.

NORMs are comprised of radioactive elements such as uranium, radium and radon, and are often present at very low concentrations during normal reactions between water and rock. The associated environmental risk is incorrect disposal of waste containing NORMs, leading to pollution of the ocean and potentially chronic and acute toxicity impacts on marine flora and fauna. Inappropriate storage, handling or disposal may also impact on human health (depending on the composition of the NORMs) if the workforce are exposed to the material, however this aspect is managed via the Safety Case regime. To be classified as hazardous radioactive material from a waste management perspective, the applicable Threshold Activity Concentration Limits (TACL) must be exceeded as defined by the relevant state and/or federal regulations. The TACL is the upper level of radioactivity prescribed by the Statutory Authority below which material may be classified as Radiological Non-Hazardous. Disposal of materials that do not exceed the defined TACL may be carried out as per general non-hazardous waste.

Habitats within the Operational Area are not considered to be particularly sensitive or of high conservation value and are well represented in the region. Given the typically small volumes of wastes that may be released during any given event, potential impacts to sensitive species are expected to be restricted to individual animals. Many of the vertebrate species considered vulnerable to waste impacts occur seasonally or are expected to occur in low densities (e.g. transiting the area).

Apart from waste streams that are permitted for discharge in accordance other sections of this EP, there are no other planned waste discharges from the FLNG facility or support vessels. Given that any direct impacts from unplanned events to receptors in the offshore environment are likely to be localised and short-term, the residual risk of waste release is assessed to be Dark Blue as per Table 9-64.

9.12.3 Risk Summary and Key Management Controls

Table 9-64: Waste Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	N/A	N/A	N/A
Biological Environment	Slight	C	Dark Blue
Socio-Economic Environment	N/A	N/A	N/A

9.12.4 ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	N/A	N/A	Waste generation cannot be eliminated from the offshore facilities.	N/A	N/A	N/A
Substitution	N/A	N/A	The use of alternative materials which will produce less wastes is part of the Product Stewardship Standards of Shell. If materials that generate less wastes are identified in the future, these will undergo appropriate assessment.	N/A	N/A	N/A
Engineering	Designated Waste Storage Areas available on Prelude.	Yes	Wastes are properly stored, secured, adequately contained and transported to avoid the risks of accidental overboard discharge or release, especially during adverse weather. The Prelude FLNG Waste Management Procedure ensures the cradle-to-grave management of wastes as required by the Shell HSSE Control Framework Manual on Waste Management.	10.1	Designated waste storage facilities on Prelude is available to enable waste to be secured and stored on facilities.	Assurance against waste management facilities, equipment and practices demonstrates that appropriate waste storage facilities have been provided and maintained.
Administrative and Procedural Controls	Required marine support vessels will maintain a Garbage Management Plan (or equivalent).	Yes	Each required marine support vessel has its own Garbage Management Plan/Procedure (or equivalent) to manage wastes generated and stored onboard. All wastes that are not permitted for discharge are sent ashore for reuse, treatment, recycling and/or disposal as appropriate. This control measure is in accordance with Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and AMSA Marine Order 95.	10.2	Marine support vessels (to which MARPOL Annex V / Marine Order 95 applies) have a current Garbage Management Plan (or equivalent).	Garbage Management Plan (or equivalent) is sighted onboard marine support vessels and are maintained up to date.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
				10.3	Marine support vessels to comply with AMSA marine order 94 & 95 (marine pollution prevention – packaged harmful substances/garbage), specifically: • No planned disposal of domestic waste, solid wastes or maintenance wastes overboard from vessels (other than planned discharges permitted by this EP)	Garbage record book maintained for marine support vessels as per Marine Order 95 demonstrates that there were no unpermitted discharges of solid waste as part of the petroleum activities.

9.12.5 Acceptability of Impacts

Receptor Category	Receptor Sub-category	Acceptable Level of Impact	Are the Impacts of an Acceptable Level?	Acceptability Assessment
Physical Environment	N/A	N/A	N/A	N/A
Biological Environment	Threatened and Migratory Species	No significant impacts to listed Threatened (Endangered and Vulnerable) or Migratory MNES fauna populations	Yes	Shell implements MARPOL standards and internal controls in relation to managing wastes, which reduces the likelihood of wastes being accidentally released to the marine environment. Given the remote location and distance from important habitats of the Operational Area, any accidental release of wastes to the environment would not be expected to interact with a large number of threatened or migratory MNES species.
Socio-economic and Cultural Environment	N/A	N/A		N/A

The assessment of risks from waste determined the residual risk rating of Dark Blue (Table 9-64). As outlined above, the acceptability of the risks from waste associated with the Prelude project has been considered in the following context.

Principles of ESD

The risks from waste are consistent with the principles of ESD based on the following points:

- The environmental values/sensitivities within the Operational Area are not expected to be significantly impacted, and
- The precautionary principle has been applied to the risk assessment.

Relevant Requirements

Management of the risks from waste are consistent with relevant legislative requirements, including:

- MARPOL Annex V as ratified by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- *Navigation Act 2012 (Cth)* and *Protection of the Sea (Prevention of Pollution) Act 1983 (Cth)*:
  - Marine Order 94 – Marine pollution prevention – packaged harmful substances
  - AMSA Marine Order 95 (marine pollution prevention – garbage).
- Radiation Safety Act 1975 (WA)
- Code of Practice for the Safe Transport of Radioactive Material (Australian Radiation Protection and Nuclear Safety Agency 2019)

- Management of impacts and risks are consistent with policies, strategies, guidelines, conservation advice, and recovery plans for threatened species (Table 9-65).

Matters of National Environmental Significance

Threatened and Migratory Species

The evaluation of waste risks indicates significant risks to threatened and migratory species will not credibly result from the waste aspect of the Prelude petroleum activities given the limited number of animals that could potentially be impacted in the unlikely event of an unplanned release.

Alignment of the Prelude petroleum activities with management plans, recovery plans and conservation advice for threatened and migratory fauna is provided in Table 9-65.

Commonwealth Marine Environment

The impacts and risks from the waste aspect of the Prelude field on the Commonwealth marine environment will not exceed any of the significant impact criteria provided in Table 8-1.

Table 9-65: Summary of Alignment of the Risks from the Waste Aspect of the Prelude Petroleum Activities with Relevant Requirements for EPBC Threatened Fauna

Matters of National Environmental Significance	MNES Acceptability Considerations (Significant Impact Criteria, EPBC Management Plans/Recovery Plans/Conservation Advices)	Threats Relevant to the Project	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species	Conservation advice on sei whale (Balaenoptera borealis) (DoE 2015c)	Pollution (persistent toxic pollutants)	Waste generated during the petroleum activities described in this EP will be managed in accordance with standard maritime requirements, international conventions (MARPOL), relevant Marine Orders and Shell's internal management system requirements. This management reduces the likelihood of the accidental release of hazardous and non-hazardous wastes into the marine environment. The frequency, quantities and nature of wastes that may be accidentally released into the environment are unlikely to result in significant impacts to threatened/migratory species or the Commonwealth Marine Environment (Table 8-1).
	Conservation advice on fin whale (Balaenoptera physalus) (DoE 2015d)	Pollution (persistent toxic pollutants)	
	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015–2025 (Commonwealth of Australia 2015a)	Habitat modification including presence of oil and gas platforms/rigs, marine debris infrastructure and acute/chronic chemical discharge	
	Conservation advice on humpback whale (Megaptera novaeangliae) (DoE 2015b)	Entanglement – marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
	Recovery Plan for Marine Turtles in Australia 2017–	Marine debris	

	2027 (Commonwealth of Australia 2017)		
	Conservation advice on leatherback turtle (Dermochelys coriacea) (DEWHA 2008)	Marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
	Conservation advice on whale shark (Rhincodon typus) (DoE 2015x)	Marine debris	
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8-1)	Marine debris	
Commonwealth Marine Area	Significant Impact Guidelines for the Commonwealth marine environment (Table 8-1)	Marine debris	
	Threat abatement plan for the impacts of marine debris on vertebrate marine life (DEWHA 2009c)	Marine debris	
Wetlands of International Importance	N/A	N/A	N/A

External Context

There have been no objections or claims raised by Relevant Persons to date around the waste aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking future assessment of risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

The assessment of and risks from waste determined the residual risk rating to be Dark Blue (Table 9-6). As outlined above, the acceptability of the impacts and risks from waste have been considered in the context of:

- The established acceptability criteria for the waste aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Shell considers residual risks of Dark Blue or lower to be inherently acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the waste aspect.

Based on the points discussed above, Shell considered the risks from waste associated with the petroleum activities described in this EP to be acceptable.

9.12.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No injury or mortality of listed Threatened or Migratory MNES species as a result of unplanned waste discharge to sea.	Fauna observations and incident reports demonstrate no mortality of listed Threatened or Migratory species as a result of unplanned waste discharged from the petroleum activities within the Operational Area.

9.13 Emergency Events

9.13.1 Scenario Context

Several unplanned events (i.e. incidents or emergencies) resulting in the potential for large-scale releases of hydrocarbons or chemicals were identified for Prelude FLNG Operations, including:

- Loss of containment (LOC) of well fluids from subsea infrastructure (e.g. production wells, manifolds, flowlines or risers)
- LOC during FLNG product storage and offloading (LNG, LPG or condensate)
- LOC of heavy fuel oil to sea from marine vessels or product offtake tankers
- LOC of diesel during refuelling or following a collision between any marine vessels operating in the field
- accidental discharge of hazardous liquids or hazardous liquid wastes (e.g. MEG, amine, helifuel, etc) during bulk liquid transfers or lifting operations.

A worst-case scenario resulting from each of these events has been considered in this environmental risk assessment. Each of these scenarios is discussed further in this Section. Each of these scenarios can result in smaller spills than the worst-case credible spills discussed below. The smaller spills have not been discussed specifically as their consequences will be lesser in both magnitude and impact.

LOC from Subsea Infrastructure

Prelude subsea infrastructure includes the seven production wells, two production manifolds and one drill centre, four production flowlines, a riser manifold and risers as well as the well control umbilical. LOC could occur from any of these facilities due to e.g. a dropped object, corrosion, erosion, human error and/ or reservoir or external environmental events that could exceed the design tolerance of any of the components of this system.

Of these events, loss of well control incidents are known to be associated with the largest potential for environmental harm due to the large volumes of hydrocarbons contained in the reservoir and the considerable amount of time it requires to drill an offset relief well and stop the flow of reservoir fluids to the environment. Loss of well control incidents are most likely to occur during well drilling or workover when there is an open path for the well fluids from the reservoir to surface and reliance is on control systems and operators to detect an abnormal situation in its incipient stages to prevent it from escalation. Such activities are not considered in scope of this EP, as such they will be addressed in standalone campaign specific EPs and associated documentation.

Production well LOC events, although rare, are still a possibility and range from minor breaches in containment (pinhole leaks from corroded/ eroded piping or valves) through to large release events similar in volume to a well blowout during drilling. Prelude operations have identified two large well breach events, most likely caused by dropped objects during future installation and hook up of subsea infrastructure, flowline and other subsea infrastructure IMR campaigns or light well intervetions, e.g.:

- a release from the 500m section of production tubing between the wellhead and the Surfce Controlled Sub-Surface Safety Valve (SCSSV). This would be a fairly limited inventory and the release durations would be expected to be relatively short.
- a release from the 500m section of production tubing whereby the SCSSV fails in the open position allowing the release to be effectively fed by the reservoir. This release will be similar to a well blowout and would continue for months unless remediated by drilling a relief well or other source control strategy.

The modelled well fluids flow rate in the second scenario is estimated at 20,000 bbl/day, yielding a total released volume of 1,600,000 bbl as the worst case credible scenario. This rate is based on the maximum rate of gas flow expected from the most productive of the seven Prelude wells during production drilling, and the number of days (80 days) to drill a relief well in the case of loss of well control. Risk assessments will be carried out on this modelling information. However, the actual worst case credible scenario during operations is 10,138 bbl/day (~1,611 m^3/day), yielding a total release volume of 811,040 bbl (~128,944 m^3) over 80 days.

The likelihood of such incidents in Australia has been very low. A report on world-wide well control incidents commissioned by the US Department of the Interior (Bercha International Inc. 2014) indicates the frequency of production well control incidents in Australia, derived from Gulf of Mexico incident data (1980 – 2014), to be 0.104 incidents per 1000 well years, or 1.04E-04 per well year. For the 7 production wells in the Prelude field, this translates into a frequency of 7.3E-04 well control events per annum, or remote likelihood of a well incident. Note that the higher the well fluids loss flowrate, the lower the frequency of well blowout in accordance with the formula derived by DNV based on historical data i.e. 6.9 x 10-5 Q-0.3 per well year, where Q is the mass of spilled hydrocarbons in tonnes (Det Norske Veritas, 2011).

All other releases from subsea infrastructure will be orders of magnitude smaller in volumes lost to sea compared to the uncontrolled production well release scenario with SCSSV faillure. These smaller release scenarios have not been discussed or modelled further.

LOC from Product Storage and Offloading

The liquid product streams on Prelude are LNG, LPG (propane and butane) and condensate. During production these are rundown to their respective cargo storage tanks within the substructure and stored at atmospheric pressure. The substructure is double hulled on each side extending over the full length of the storage tanks. LNG, LPG and condensate storage tanks are located inboard of segregated ballast tanks covering the full length of the storage area and are separated from each other by either a void space or a ballast tank. In addition, the tanks are protected from the topsides hazards by a main deck designed to withstand explosion overpressure, jet fire and cryogenic spills. A heating system is installed to heat the transverse cofferdams and the upper portion of the centreline water ballast tanks surrounding the cargo tanks to maintain the temperature of the structure and prevent brittle failure.

LNG or LPG leaks from the topsides process modules or any hydrocarbon release from the cryogenic areas of the plant are directed to sea to protect the facility from damage due to cryogenic spills and prevent process safety incidents and escalation. Topsides condensate spills on the FLNG, however, are designed to be captured and contained in the drainage system (Appendix 12.0) and reclaimed back into the process where possible or disposed of appropriately.

Only a single product stream is offloaded at any one time.

LOC from LNG and LPG Storage and Loading

The FLNG Ship Collision Study and Collision Analysis for Substructure indicate a remote to extremely remote liklihood of ship collision as detailed in the Prelude FLNG Safety Case (Shell Australia 2017). The overall collision frequencies are dominated by the contribution of the low energy on approach supply and product offtake vessels, which would cause no breach of the outer hull but localised damage only.

For a loss of containment of LNG, LPG or condensate product from a single cargo tank to occur, collision energy levels between 193 and 500 MJ should be imparted to the FLNG hull. Energy levels greater than 500 MJ could cause extensive hull damage with release of large volumes of products. These high-energy impacts could only be associated with large passing vessels travelling at cruise speed.

Based on known shipping routes and annual traffic through the Prelude area, the annual frequency of collisions resulting in single storage tank failure and loss of containment is estimated at 4.7E-05/year and the catastrophic FLNG vessel failure frequency is 3.8E-05/year (Shell Australia 2017).

Smaller volume LNG and LPG spills could occur during LNG or LPG loading. LNG loading occurs each week at the dedicated Prelude LNG loading platform, typically over the course of 24 hrs, at a maximum combined loading rate of 10,000 m^3/h. LPG loading occurs once a month at a rate of 3000 m^3/h.

An LNG or LPG spill could result from e.g. inadvertent move of the FLNG or LNG/ LPG tanker beyond the design tolerance of the loading arms, causing arm disconnection, parting or failure; material failure due to corrosion, erosion; temperature embrittlement; overpressure or dynamic loading from product fluids, adverse weather, etc.

At the end of an LNG/ LPG carrier loading the loading arms are emptied forward to the carrier. Then the LNG/ LPG offloading header and offloading arm manifolds are drained to the LNG/ LPG storage tanks assisted by nitrogen purge. In the event of an emergency during loading, the loading header is emptied to the tanks by gravity.

LNG and LPG are gases at ambient temperatures, hence any LOC from the cargo tanks or during loading will ultimately result in loss to atmosphere and therefore cause no damage to the marine environment. The main concern with such events is the potential for fires or explosions presenting risks to personnel and property and these are addressed in the Prelude FLNG Safety Case. Environmental risks related to such releases are therefore considered non-credible and have not been discussed further.

LOC from Condensate Storage and Loading

Six atmospheric pressure condensate storage tanks are located in the aft section of the FLNG hull. Each tank has a capacity of 21,054 m^3 at 95% full and is supplied with two offloading pumps. During offloading mode all twelve offloading pumps are expected to be in operation, delivering condensate at a rate of 5,000m^3/hr to the condensate tanker. This allows offloading of up to 120,000 m^3 of condensate (net total pumpable condensate tanks storage capacity) in 24 hours. Condensate loading occurs approximately once every two weeks.

A stern tandem offloading arrangement for the discharge of condensate is provided at the aft end of Prelude. Condensate tankers are designed to be moored in the conventional manner for Single Point Mooring (SPM) bow mooring terminals with a standard OCIMF single braided (DN 400/DN 500) floating hose string deployed to the standard mid-ship manifold. Berthing utilises a hawser and hold-back support vessel rather than dynamic positioning. The condensate floating hose is stowed on an aft hose reel for controlled deployment and recovery. After offloading the remaining condensate in the hose is transferred back to the condensate tank by N_2 purge. A washing system is provided to allow washing of the hose back to the slops tanks to minimise build-up of waxy deposits within the hose.

Condensate is a liquid at ambient temperature and pressure. It is comprised of low molecular weight hydrocarbons and has similar characteristics as light diesel fuel. It is typically volatile and evaporates readily. However, Prelude condensate has a significant waxy component which may persist after the volatile portion evaporates.

Condensate containment losses from FLNG operations have been estimated as follows:

- Up to 10m^3 from inadvertent disconnection of a coupling or flange at the topsides process modules and failure to contain by spill trays and the drain system;
- Up to 1000m^3 for condensate offloading operation by floating hose. At a loading rate of 5,000m^3 per hour, these quantities reflect a major loss of containment from rupture of loading hose and failure to respond within 15 minutes; or
- Release of cargo due to a high impact vessel collision and breach of hull and storage tank containment. A 42,000m^3 release of condensate released over a period of 2 hours has been considered.

The last scenario is considered as the worst-case credible scenario and has been modelled for impact assessment purposes.

LOC of Heavy Fuel Oil / Intermediate Fuel Oil

The product offtake tankers could potentially carry heavy fuel oil (HFO)/ Intermediate Fuel Oil (IFO) as fuel. Any HFO/ IFO spill will result from a tanker collision with other vessels such as other tankers or an attendant vessel during berthing or unberthing operations as a result of e.g. human error, adverse sea/ weather conditions, loss of navigation aid systems, mechanical breakdown, miscommunicaion or tug failure.

Given the average volume of HFO/IFO stored in LNG carriers (up to 5,000 m^3) and the low energy collision credible during berthing/ unberthing, a 1,000 m^3 HFO spill was modelled. This is considered highly conservative given impact energy is highly unlikely to result in a HFO/ IFO tank breach.

LOC of Diesel

A diesel spill to the Operational Area could occur as as outcome from:

- LOC during diesel transfer from the supply vessel to the FLNG facility; or during refuelling of the pilot tugs; or
- following a collision between any marine vessels, including the FLNG facility, operating in the field.

Diesel will be loaded onto the FLNG facility from support vessels approximately once per month. This refuelling operation takes at least 4 hours per to complete. A spill could occur as a result of any of engineering controls failure (e.g. hose rupture, coupling failures, tank overflow) or human error. However, historically the volume lost to sea in similar incidents is typically less than 160 litres or 1 bbl (Det Norske Veritas, 2011) and potential further losses are reduced by visual observations, shutdown of pumps and automatic closure of safety valves.

The risk of a spill from vessel to vessel collision depends on the severity of impact, i.e. the speed and orientation of the vessels during the event. The worst-case scenario is where one of the vessels is ‘hit’ from the broadside by another vessel moving at near full speed resulting in a puncture of the diesel tanks below the waterline.

Prelude marine support vessels have diesel storage capacities of around 1,000 m^3, spread in multiple tanks. Pilot tugs carry similar or smaller diesel inventories onboard. The likelihood of collision between supply and support vessels and any other vessels in the field is considered remote given the low frequency of vessel collisions in ports resulting in fuel loss of containment (Det Norske Veritas, 2011) further reduced by the fact that the Operational Area is far less busy than any other Australian or international port.

The largest diesel volume spill scenario is considered to be from a supply vessel collision with the FLNG facility of magnitude such that a breach of the hull and damage to its biggest diesel storage tank would occur. The tank is located in the FLNG facility substructure and has a capacity of 750 m^3. It has been conservatively assumed for the purposes of spill modelling that in the remote chance of this happening, the whole inventory of this tank would be lost to sea. The likelihood of this event happening is estimated as remote given no such events have occurred in Shell or are known of in the industry.

LOC of Hazardous Liquids

Accidental loss to sea of hazardous liquids other than hydrocarbons (e.g. amine, MEG, hydraulic/ lube oil etc.) could occur at the Prelude location due to any of the following events:

- accidental opening of an isolation valve during normal operations
- hose failure or failure to isolate inventory during bulk liquid transfers
- lifting operations between marine vessels, including the FLNG
- adverse weather conditions resulting in dislodgement/ failure of storage vessel(s).

The worst-case spill scenarios for amine and MEG are summarised as follows:

- a 1-hour release of 1,000m^3 of amine (methyl-diethanolamine (MDEA) containing 10-30% Piperazine) at sea surface following a complete rupture of the FLNG amine storage tank.
- a 1-hr 6,000 m^3 release of MEG (80% pure MEG and 20% seawater) at sea surface following a complete rupture of the FLNG MEG storage tank.

The likelihood of such events are expected to be low.

9.13.2 Overview of Unplanned Spill Modelling

Numerical modelling studies were commissioned for the worst-case credible spill scenarios outlined above.

Table 9-66: Summary of Modelled Hydrocarbon and Hazardous Liquids Scenarios

Scenario	Location Name	Latitude	Longitude	Depth (m)	Hazardous Liquid	Duration	Total Volume (m³)
Loss of well control	Prelude Production Well	13°50"22" S	123°19"35.8" E	237	Well fluid	80 days	254,400
Loss of containment during product offloading (collision)	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Condensate	2 hours	42,000
Loss of containment of heavy fuel oil	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	HFO	1 hour	1,000
Loss of containment of diesel	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Diesel	1 hour	750
Loss of containment of amine	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	Amine	1 hour	1,000
Loss of containment of MEG	Prelude FLNG	13°47.2´S	123°19.0´ E.	surface	MEG	1 hour	6,000

The following models were used to predict impacts from these scenarios:

- Loss of well control was modelled using the Integrated Oil Spill Impact Model System (SIMAP) model with each simulation run for 108 days.
- Condensate and HFO spills were modelled using SIMAP, whereby 100 replicates over 4 seasons were run for 56 days each.
- The diesel spill scenario was modelled using the OILMAP-Deep model for nearfield modelling and the SIMAP model for the far field effects. 200 replicates over four seasons were run.
- Amine and MEG spill modelling were carried out using the three-dimensional chemical spill trajectory and weathering model, CHEMMAP (Chemical Mapping and Analysis Program). Amine and MEG modelling used 100 replicates per two seasons (summer and winter). In the case of amine, each simulation was run for 5 days, whilst for MEG, it was run for 4 days.

SIMAP and CHEMMAP represent 3D stochastic models, with physical fates component for oils and chemicals, biological effects and exposure component, GIS component, and environmental features, oil/ chemical and biological databases. OILMAP-Deep is a 2D/3D deterministic model, simulating the fate of oil in the environment (surface, water colomn and air distribution), interactions with the ecological component of the environment and has a stochastic component which determines the probability and time contours of oiling of the various environmental components and the most likely spill paths on a monthly, seasonal, or annual basis. The metocean conditions used as input to each model were derived from a 39-year data set of current speed and direction at half-hourly intervals.

A stochastic modelling scheme was followed for each modelled scenario, whereby the respective model was applied to repeatedly simulate the defined spill scenario using different samples of current and wind data. Starting dates for each simuation were distibuted between the seasons (e.g. summer and winter) to capture the influence of the temporal and spatial variations in the current patterns that would affect the trajectory of any hydrocarbon or chemical spills that commenced in these periods. The results of the replicate simulations were then statistically analysed and mapped to define contours of risk around the release point.

For hydrocarbons, the timeseries contour compilations include floating, entrained, dissolved and accumulated hydrocarbons.

Hydrocarbon Impact Thresholds

Spilled hydrocarbons can exist as floating, entrained, dissolved and accumulated (i.e. stranded onshore) hydrocarbons. Each of these fractions/ phases can interact with the environment in diverse ways due to different pathways to receptors and cause/effect mechanisms. Guideline impact thresholds (NOPSEMA 2019b) for floating, entrained, dissolved and accumulated hydrocarbons were applied to the hydrocarbon spill modelling studies and used to inform the assessment of potential impacts and risks. Three thresholds were applied to each phase i.e. low exposure, moderate exposure and high exposure. These are described in Table 9-67 and are used to delineate the extent (outer edge) of the low, moderate or high exposure zones for each hydrocarbon type. The low, moderate and high exposure zones represent bands/ ranges of hydrocarbon concentrations, grouped on the basis of scientific knowledge of potential impacts of the various hydrocarbon phases on environmental receptors.

Table 9-67: Hydrocarbon Exposure Zones and Thresholds

Exposure Zone	Threshold	Justification
Floating Oil		
Exposure Zone Low (1 g/m^2 – 10 g/m^2)	1 g/m^2	The 1 g/m^2 threshold represents the practical limit of observing hydrocarbon sheens in the marine environment and therefore has been used to define the outer boundary of the low exposure zone. This threshold is considered below levels which would cause environmental harm and is more indicative of the areas perceived to be affected due to its visibility on the sea-surface. This exposure zone represents the area contacted by the spill and defines the conservative outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone	10 g/m^2	Ecological impact has been estimated to occur at 10 g/m^2 as this level of oiling has been observed to mortally impact birds and

Exposure Zone	Threshold	Justification
Moderate (10 g/m^2 – 25 g/m^2)		other wildlife associated with the water surface (French et al. 1996; French 2000). Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 25 g/m^2)	25 g/m^2	The 25 g/m^2 threshold is above the minimum threshold observed to cause ecological impact. Studies have indicated that a concentration of surface oil 25 g/m^2 or greater would be harmful for the majority of birds that contact the hydrocarbon at this concentration (Koops et al. 2004; Scholten et al. 1996). Exposure above this threshold is used to define the high exposure zone.
Accumulated (Shoreline) Oil		
Exposure zone Low (10 g/m^2 – 100 g/m^2)	10 g/m^2	A threshold of 10 g/m^2 has been defined as the zone of potential 'low' exposure. This exposure zone represents the area visibly contacted by the spill and defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (100 g/m^2 – 1,000 g/m^2)	100 g/m^2	French et al. (1996) and French-McCay (2009) have defined an oil exposure threshold of 100 g/m^2 for shorebirds and wildlife (furbearing aquatic mammals and marine reptiles) on or along the shore, which is based on studies for sub-lethal and lethal impacts. The 100 g/m^2 threshold has been used in previous environmental risk assessment studies (French et al. 2011; French-McCay 2004; French-McCay 2003; French McCay et al. 2012; National Oceanic and Atmospheric Administration 2013). This threshold is also recommended in AMSA's foreshore assessment guide as the acceptable minimum thickness that does not inhibit the potential for recovery and below which is best remediated by natural coastal processes alone (AMSA 2015). Thresholds of 100 g/m^2 and 1,000 g/m^2 will define the zones of potential 'moderate' and 'high' exposure on shorelines, respectively. Contact within these exposure zones may result in impacts to the marine environment and coastal areas.
Adverse exposure zone High (> 1,000 g/m^2)	1,000 g/m^2	
Entrained Hydrocarbons		
Exposure zone Low exposure (10 parts per billion (ppb)–100 ppb)	10 ppb	The 10 ppb threshold represents the lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC & ARMCANZ (2000) water quality guidelines. Due to the requirement for relatively long exposure times (> 24 hours) for these concentrations to have an observable impact, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained oil plumes, or when entrained hydrocarbons adhere to organisms or entrained oil is trapped against a shoreline for periods of several days or more. This exposure zone is not considered to be of significant biological impact. This exposure zone represents the area contacted by the spill and conservatively defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (100 ppb–500 ppb)	100 ppb	The 100 ppb threshold is considered conservative in terms of potential for toxic effects leading to mortality for sensitive mature individuals and early life stages of species. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations.

Exposure Zone	Threshold	Justification
		The 100 ppb threshold has been selected to define the moderate exposure zone. Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 500 ppb)	500 ppb	The 500 ppb threshold is considered a conservative high exposure level in terms of potential for toxic effects leading to mortality for more tolerant species or habitats. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations. The 500 ppb threshold has been selected to define the high exposure zone.
Dissolved Aromatic Hydrocarbons		
Exposure zone Low (6 ppb–50 ppb)	6 ppb	The threshold value for species toxicity in the water column is based on global data from French et al. (1999) and French-McCay (2003, 2002), which show that species sensitivity (fish and invertebrates) to dissolved aromatics exposure > 4 days (96-hour LC50) under different environmental conditions varied from 6 ppb–400 ppb, with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae). Based on scientific literature, a minimum threshold of 6 ppb is used to define the low exposure zones (Clark 1984; Engelhardt 1983; Geraci and St Aubin 1988; Jenssen 1994; Tsvetnenko 1998). This exposure zone is not considered to be of significant biological impact and conservatively defines the outer boundary of the ZPI from a hydrocarbon spill.
Adverse exposure zone Moderate (50 ppb–400 ppb)	50 ppb	A conservative threshold of 50 ppb was chosen as it is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002). French-McCay (2002) indicates that an average 96-hour LC50 of 50 ppb could serve as an acute lethal threshold to 5% of biota. The 50 ppb threshold has been selected to define the moderate exposure zone. Contact within this exposure zone may result in impacts to the marine environment.
Adverse exposure zone High (> 400 ppb)	400 ppb	A conservative threshold of 400 ppb was chosen as it is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002). French-McCay (2002) indicates that an average 96-hour LC50 of 400 ppb could serve as an acute lethal threshold to 50% of biota. The 400 ppb threshold has been selected to define the high exposure zone.

The dissolved aromatic hydrocarbon impact thresholds presented in Table 9-67 are considered conservative and appropriate for the assessment of impacts on marine receptors given evidence on impacts from additional ecotoxicity studies. For example, the Browse Joint Venture (JV) ecotoxicity testing of Calliance condensate (ESA, cited in Woodside Energy Limited, 2013) on a broad range of taxa of ecological relevance indicated no observed effect concentrations were achieved at concentrations orders of magnitude greater than the 400 ppb threshold for the High Exposure Zone. Calliance condensate is considered to be broadly similar to Prelude condensate given a similar location, geology, formation, and depth.

Calliance ecotox testing (Woodside Energy Limited, 2013) showed results for no observed effect concentrations per Table 9-68 below:

Table 9-68: Browse JV Ecotox testing on Calliance Condensate

Biota and life stage	Exposure duration	NOEC – dissolved aromatic concentration of unweathered Calliance condensate showing no direct biological affect (ppb)
Sea urchin fertilisation	1 hour	13,360
Sea urchin larval development	72 hours	32,360
Macroalgal germination	72 hours	44,950
Microalgal growth test	72 hours	24,270
Rock oyster spat survival test	48 hours	32,360
Tiger prawn acute toxicity test	72 hours	1280
Larval fish imbalance test	96 hours	1280

**Source: Table 5-5 from Woodside's Outer Canning Exploration Drilling Program Environment Plan (Woodside 2013).*

The dissolved and entrained thresholds are instantaneous measures and based on the results of testing presented in table above are highly conservative. These thresholds are also considered appropriate for diesel and HFO/ IFO given the similarity in cause effect pathways.

Chemical (Amine and MEG) Impact Thresholds

Environmental threshold values for amine were developed from literature, following the ANZECC Guidelines (2000; 2018). An ecotoxicity value was derived for amine's main component, MDEA, by identifying previous studies with ecotoxicity results for marine organisms and using the ANZECC Guidelines to derive a threshold. Five ecotoxicity thresholds were identified from different sources, which were used to determine a moderate reliability threshold of 1.8 mg/L, which is the lowest LC50 value in Table 9-69 divided by 100.

Table 9-69: The acute or chronic toxicity of different aquatic organisms and the time period of exposure

Organism (species)	Source	Type of Acute or Chronic Toxicity	Exposure Time Period (hour)	Toxicity Value (mg/L)
Fish (unknown)	MSDS	LC50	Not specified in study	1,466
Algae (skeletonema costatum)	Hansen et al	EC50	48	141.4
Zooplankton (Calanus finmarchicus)	Hansen et al	LC50	Not specified in study	183.4
Algae/bacteria (Vibrio fischeri)	Brooks, 2008	EC10	0.25	36
Carp (Cyprinidae)	Brooks, 2008	LOEC	Not specified in study	0.5

For MEG, which is classified as "practically non-toxic" to aquatic organisms by the U.S. Environmental Protection Agency (USEPA) and PLONOR under the OSPAR Commission, the Predicted No Effect Concentration (PNEC) of 859 mg/L, recommended by the World Health Organisation (WHO 2000), was used in assessing modelling outcomes. The MEG PNEC was derived from the No Observed Effect Concentration (NOEC) of 8590 mg/L for chronic exposure of daphnids (reproductive end point assessment) divided by a safety factor of 10 (WHO 2000). This concentration is two orders of magnitude lower than MEG's LC_{50} values for other aquatic organisms (e.g. aquatic invertebrates, fish and tadpoles, in WHO 2000) and is therefore considered appropriate. The chemical is also considered as non-persistent in the environment and does not bioaccumulate (Staples et al. 2001).

9.13.3 Summary of Loss of Containment Modelling Results

Loss of Well Control

A loss of containment due to loss of well control will involve the turbulent discharge of gas and condensate at the seabed through a restriction (the well head). The condensate will be discharged as a jet of small droplets into the water column (237 m below sea level) which would be carried forth and upwards to the sea surface by the buoyancy of the gas cloud, which will be counteracted by the viscous resistance imparted by the surrounding seawater. Where the release occurs at water depths exceeding 100-200 m, the gas plume would lose its momentum prior to breaking through to the surface and the entrained oil droplets may become trapped by the density layers in the water column (Chen & Yapa, 2002).

Thus, for deeper releases (>200 m), the gas and oil will tend to separate before the oil surfaces because the gas either goes into solution or accelerates away from the oil droplets. The height at which the gas lift ceases is referred to as the trapping height. The rate at which oil rises from the trapping height will be determined by a number of factors, including the relative buoyancy of the oil versus local water density, the size of the droplets (increased viscous resistance for smaller sizes), the presence of density barriers in the water column and the action of shear currents that might be present in that location.

The Prelude OILMAP-Deep model included specification of the discharge rate, hole size, gas-to-oil ratio, the temperature of the oil on exiting and before subsequent cooling by the ambient water. The temperature and salinity profiles of the water column were also specified to describe the vertical density profile.

The plume trapping height (where the gas lift ceases) was estimated at approximately 213 m above seabed, hence approximately 24 m below sea level. The diameter of the water and condensate plume at this level was estimated at approximately 27.1 m. Based on the small oil droplet sizes forecast by OILMAP-Deep (15.1-90.0 µm), the droplets will then rise slowly at a net rate determined by their buoyancy relative to the surrounding water density and the viscous resistance imposed by the water. The results essentially suggest that the majority of the oil will be entrained into the upper mixed layer of the ocean, with some surfacing potential based on the proportion of larger droplets.

Key results from the SIMAP stochastic modelling studies for a worst-case loss of well control LOC showed:

- **Floating hydrocarbons** will predominantly surface in the immediate vicinity of the release site with concentrations above the low exposure threshold most frequently occurring in waters to the northwest and southeast, with the furthest travelled distance from the release site being to the north-northeast and the west-southwest. Concentrations of floating oil ≥1 g/m2 could potentially be found up to 875 km to the west-northwest of the release site. The 10 g/m2 threshold is contained within 10 km from the release site, whilst the high exposure threshold is never exceeded. The annualised probability of floating oil at concentrations of 1 g/m² or greater reaching nearshore waters is predicted to be 6% at Browse Island, 5% at Heywood Shoals, 4% at Echuca Shoals and ≤3% for all other assessed sensitive receptors. Probability of contact <0.5% is predicted for nearshore waters to all sensitive receptors by floating oil concentrations of 10 g/m² or greater.

- The highest maximum local **accumulated shoreline concentration** from the single worst case modelling run is predicted at the Indonesian Boundary receptor at 3 kg/m², and the highest maximum local accumulated shoreline volume is also predicted for this receptor at 51 m³, ~0.02% of spilled volume. The probability of contact of floating oil film with this receptor from all replica runs is predicted to be less than 0.5%.
- For Australian receptors, the highest maximum local **accumulated shoreline concentration** from the single worst case modelling run is predicted at the Buccaneer Archipelago at 123 g/m², and the highest maximum local accumulated shoreline volume is also predicted for this receptor at 1.1 m³. The probability of contact of floating oil film with this receptor from all replica runs is predicted to be less than 0.5%.
- **Entrained hydrocarbon** concentrations above 10 ppb were predicted to potentially reach waters 2,200 km to the west of the release site and to waters south of Shark Bay (1,800 km southwest) The forecast maximum potential extent for entrained concentrations above the 100 ppb moderate exposure threshold is also around 2,200 km to the west of the release site and as far southwest as waters off Bernier and Dorre Islands (~1,500 km southwest). At the highest threshold of 500 ppb, the forecast maximum potential extent is also up to around 2,000 km west of the release site and as far southwest as North West Cape (1,200 km southwest). The highest annualised probabilities for entrained concentrations ≥10 ppb contacting the nearshore waters of receptors are predicted for Heywood Shoals (96%), Browse Island (94%) and Echuca Shoals (94%). Probabilities for contact of >80% are also indicated for the nearshore waters of Ashmore Reef (89%), Cartier Island (87%), Barracouta Shoals (87%), Vulcan Shoals (86%), Seringapatam Reef (84%), Hibernia Reef (84%) and Fantome Shoals (83%). Highest probabilities for contact at 100 ppb or greater are predicted for Browse Island (90%) and for contact above 500 ppb, a highest probability of 83% is indicated, also for Browse Island.
- **Dissolved aromatic hydrocarbons** follow similar directions to those outlined for the entrained condensate. The annualised outer contours of probability indicate the potential for concentrations at or above 6 ppb to occur in waters up to 2,000 km to the west-northwest of the release site. The forecast maximum potential extent for dissolved aromatic hydrocarbons ≥50 ppb could also stretch in isolated patches up to 2,000 km west of the site. At a threshold of 400 ppb, the predicted maximum extent reduces to around 1,500 km west-northwest of the release site in isolated transient patches. The highest annualised probability for concentrations of at least 6 ppb in the nearshore waters of receptors is forecast for Ashmore Reef at 94%. Risks for contact of 90% or above are also indicated for nearshore waters of Echuca Shoals (92%), Heywood Shoals (92%), Cartier Island (92%), Browse Island (90%) and Barracouta Shoals (90%). For contact by plumes with concentrations of at least 50 ppb and 400 ppb, the highest probabilities are predicted at 79% and 30%, respectively, for the nearshore waters of Browse Island. The maximum dissolved aromatic hydrocarbon concentration, at any depth, is also forecast for the Browse Island receptor at 7,815 ppb (~7.8 ppm).

Figure 9-22: Extent of the ZPI (low exposure threshold) and the moderate exposure thresholds (floating, dissolved and entrained) based on the stochastic results of all worst case credible spill scenarios combined

Condensate Spill

Key results from the SIMAP stochastic modelling study (APASA 2014) for the worst-case condensate LOC event during offloading operations showed:

- **Floating oil** at or above 1 g/m^2 is forecast to extend up to 820 km to the west of the release site and up to 650 km to the north or southwest of the release site. The 10 g/m^2 contour is forecast to extend up to 460 km west / southwest and north / northwest and distances of up to 330 km west / southwest and 370 km north of the release site for the 25 g/m^2 contour. The probability of contact for low, moderate and high exposure thresholds for the nearest sensitive receptors at Browse Island is 6.25%, 2.75% and 1.75% respectively.
- The **maximum accumulated shoreline concentration** from the single worst case run is forecast at the Indonesian Boundary at 3.1 kg/m^2 with the maximum accumulated shoreline volume being 1,393m^3 at this receptor. The probability of floating oil contact with the Indonesian Boundary (cumulative from all runs) is predicted at less than 0.5%.
- The **maximum accumulated shoreline concentration** from the single worst case run for the Australian shoreline is predicted at the Buccaneer Archipelago at 0.7 kg/m^2 along with a maximum accumulated shoreline volume of 14m^3. The probability of floating oil contact with this sensitive receptor (cumulative from all runs) is predicted to be less than 0.5%.
- **Entrained oil** at or above 10 ppb is forecast to extend up to 1,850 km to the northwest, 850 km to the northeast and 1,150 km to the southwest of the release site. At the 100 ppb threshold, the potential extent is comparable to the lower threshold but the probabilities of occurrence decrease. Entrained oil at or above 500 ppb is generally forecast to extend up to 900 km from the release site, with the potential of extending up to 1,700 km to the west-northwest.
- **Dissolved aromatic hydrocarbon concentrations** at or above 6 ppb are forecast to extend up to 1,300 km to the west-northwest and 800 km to the southwest of the release site. At the 50 ppb threshold, dissolved aromatic hydrocarbons are forecast to extend up to 700 km, with the potential occurrence of isolated patches at further distances. Concentrations at or above 400 ppb are generally forecast to extend up to 300 km from the release site, with the potential of extending up to 600 km to the southwest.

Heavy Fuel Oil Spill

The CHEMMAP stochastic modelling study (APASA, 2014b) for the 1 hr surface 1,000 m^3 HFO/ IFO spill event due to ship collision at the Prelude location, modelled over the summer and winter seasons resulted in the following findings:

- The potential **floating oil** exposure zones were shown up to 1700 km west / northwest, 500 km east/northeast and 300 km east/northeast of the release location at the low, moderate and high thresholds respectively.
- The **maximum accumulated shoreline concentration** within Australian territory is forecast at the Archipelago (Buccaneer) at 13.3 kg/m^2. The maximum accumulated shoreline volume is also forecast at this receptor at 476 m^3. At the Indonesian Boundary, the maximum accumuated shoreline concentration (averaged over all replicate runs) is forecast at 23 g/m^2, with maximum accumulated shoreline volume (averaged over all replicate runs) at 21m^3.
- **Entrained oil** at or above 10 ppb is forecast to extend up to 20 km from the release site with probabilities of threshold exceedance less than 5% at this distance. At the 100 ppb threshold, the potential extent is reduced to within 5 km of the release site. Entrained oil is not forecast at or above 500 ppb within the model domain.

- Plumes of **dissolved aromatic hydrocarbons** with concentrations of 6 ppb or greater were not forecast to occur within the model domain or within any of the assessed sensitive receptors.

Diesel Spill

The worst-case diesel spill modelling scenario included 1 hr surface 750m^3 release of Marine Diesel Oil (MDO), nearfield modelling with OILMAP-Deep and SIMAP model which included 200 replicates per four seasons (APASA, 2014c). The key modelling results include:

- The potential **floating oil** exposure zones were shown up to 500km in the south-southwest direction and 60 km and 10 km from the release location at the low, moderate and high thresholds respectively. The probability of floating oil film contact with Browse Island is 2%, Echuca Shoals 2.5%, Heywood Shoal 1% and less than 0.5% at all other sensitive receptor locations.
- The annualised **maximum accumulated volume** averaged over all replicate spills is 0.7 m^3, 0.4 m^3, 0.07 m^3 and 0.09 m^3 at Browse Island, Scott Reef, Ashmore Reef and Cartier Island respectively, with no contact at any other emergent features. The maximum local accumulation averaged among replicate spills is 25 g/m^2 at Browse Island, 7.2g/m^2 at Cartier Island and 5.5 g/m^2 at Scott Reef, with less than 1 g/m^2 at all other emergent features.
- The 100 ppb **entrained oil** annualised probability at the closest sensitive receptors is 3% for Browse Island, 4% for Heywood Shoal and 2% for Echuca Shoals with 1% or less for all other receptors. The probability of contact with entrained oil at the high exposure level of 500ppb is less than 0.5% at all sensitivities.
- The annualised probability of exposure to **dissolved aromatic hydrocarbons** at the low exposure threshold of 6 ppb is 2% at Browse Island and 1% at Heywood and Echuca shoals. For all other sensitive locations, this exposure probability is less than 0.5%. Annualised probabilities for the moderate and high exposure thresholds of 50 ppb and 400 ppb are less than 0.5% at all sensitivities.

MEG Spill

The CHEMMAP stochastic modelling study (APASA, 2019a) for the 1 hour 6,000 m^3 MEG spill event during chemical loading operations shows dissolved MEG at or above 859 mg/L (PNEC) is forecast to potentially occur at distances up to 8 km to the east and 7 km to the west of the release site over both seasons. Easterly trajectories are forecast to be more dominant in summer months, with concentrations at or above threshold predicted up to 7 km from the release site to the west. During winter months, westerly trajectories are forecast to be more dominant, with concentrations at or above threshold predicted up to 6 km from the release site to the northeast. Dissolved MEG is not forecast to contact any of the sensitive receptors at or above 50 mg/L in any season.

Amine Spill

The CHEMMAP stochastic modelling study (APASA, 2014a) for the 1 hr surface 1,000 m^3 amine spill event predicts the 1.8 mg/L dissolved amine concentration to extend over 78 km to the northeast and over 70 km to the southwest of the release site over both seasons. The probability of contact of the amine plume with Browse Island was highest during the winter season at 2% and falls down to 1% over the entire year. The single event worst case contact concentration was predicted to be 13.9 mg/L and occurred in the winter period. Similar concentrations and probabilities of contact are likely for the Heywood Shoals; however the contact is likely to be of lower likelihood and short duration. A spill of amine may drift over the closest two KEFs (Continental

Slope Demersal Fish Communities and Ancient Coastline at 125 m depth contour), however given these two receptors are located sub-surface in considerable water depth, this is unlikely to lead to any environmental effects or damage given the expected positive buoyancy of the plume.

9.13.4 Description and Evaluation of Impacts and Risks

Table 9-70: Summary of Combined Hydrocarbon Spill Modelling Results for Sensitive Receptors with Contact above Moderate Exposure Thresholds and Chemical Spill Modelling Results

Geographical Receptor Location	Distance from Operational Area [km]	EP Section Ref.	HC Concentration Above Moderate Exposure Thresholds			Potential Exposure to Amine > 1.8 mg/L	Potential Exposure to MEG > 859 mg/L
			Floating	Accumulated (Shoreline)	Entrained/ Dissolved		
Key Benthic Communities							
Browse Island	39	Section 7.2.1	Yes	Yes	Yes	Yes	No
Echuca Shoal	61		Yes	-	Yes	Yes	No
Heywood Shoal	81		Yes	-	Yes	No	No
Cartier Islet	136		Yes	No	Yes	No	No
Seringapatam Reef	136		Yes	-	Yes	No	No
Goeree Shoal	144		Yes	-	Yes	No	No
Vulcan Shoal	146		Yes	-	Yes	No	No
Scott Reef	159		Yes	No	Yes	No	No
Ashmore Reef	169		Yes	No	Yes	No	No
Hibernia Reef	194		Yes	-	Yes	No	No
KEFs							
Continental Slope Demersal Fish Communities	14	Section 7.2.3	Yes	-	Yes	Yes	No
Ancient coastline at 125 m depth contour	41		Yes	-	Yes	Yes	No
Seringapatam Reef and Clth waters in the Scott Reef Complex	131		Yes	-	Yes	No	No
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	134		Yes	No	Yes	No	No
Carbonate bank and terrace system of the Sahul Shelf	206		Yes	-	Yes	No	No
Canyons linking the Argo Abyssal Plain with the Scott Plateau	384		No	-	Yes	No	No
Pinnacles of the Bonaparte Basin	457		No	-	Yes	No	No
Mermaid Reef and Clth waters surrounding Rowley Shoals	523		No	-	Yes	No	No
Glomar Shoals	941		No	-	Yes	No	No
Exmouth Plateau	1,127		No	-	Yes	No	No
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	1,256		No	-	Yes	No	No
Commonwealth waters adjacent to Ningaloo Reef	1,304		No	-	Yes	No	No

Demersal slope and associated fish communities of the Central Western Province	1,747		No	-	No	No	No
Western rock lobster	1,862		No	-	No	No	No
RAMSAR Wetlands							
Ashmore reef national nature reserve	162	Section 7.2.5	Yes	No	Yes	No	No
Roebuck bay	474		No	No	Yes	No	No
Eighty-mile beach	610		No	No	Yes	No	No
Commonwealth Marine Area							
Commonwealth Marine Environment - Kimberley multiple use zone - Ashmore Reef recreational use zone & Sanctuary zone - Cartier Island Sanctuary zone - Oceanic shaols multiple use zone	0	Section 7.2.6	Yes	-	Yes	Yes	Yes
WA Mainland Coastline							
WA mainland coastline - Camden Sound	<200km	Section 7.2.7	Yes	Yes	Yes	No	No
BIAs and Habitat Critical for the Survival of a Species							
Blue and pygmy blue whales	Migration - 78	Section 7.2.8.2	Yes	-	Yes	Yes	No
	Foraging - 132		Yes	-	Yes	No	No
Humpback whale	Migration - 145		Yes	-	Yes	No	No
	Calving - 145		Yes	-	Yes	No	No
	Resting - 145		Yes	-	Yes	No	No
	Nursing - 145		Yes	-	Yes	No	No
	Migration (north and south) - 327		No	-	Yes	No	No
Dugong	Foraging (high density seagrass beds) - 168		Yes	-	Yes	No	No
	Foraging - 176		Yes	-	Yes	No	No
	Calving - 176		Yes	-	Yes	No	No
	Breeding - 176		Yes	-	Yes	No	No
	Nursing - 176		Yes	-	Yes	No	No
Australian snubfin dolphin	Foraging - 187		No	-	Yes	No	No
	Breeding - 190		No	-	Yes	No	No

	Foraging (high density prey) - 190		No	-	Yes	No	No
	Calving - 190		No	-	Yes	No	No
	Resting - 190		No	-	Yes	No	No
Indo-Pacific humpback dolphin	Foraging - 190		No	-	Yes	No	No
	Calving - 190		No	-	Yes	No	No
	Breeding - 190		No	-	Yes	No	No
	Foraging (high density prey) - 190		No	-	Yes	No	No
	Significant habitat - unknown behaviour - 247		No	-	Yes	No	No
Indo-Pacific/spotted bottlenose dolphin	Calving - 190		No	-	Yes	No	No
	Foraging - 190		No	-	Yes	No	No
	Breeding - 239		No	-	Yes	No	No
Flatback turtle	Inter-nesting buffer - 268		No	-	Yes	No	No
	Foraging - 344		Yes	-	Yes	No	No
	Nesting - 302		No	No	Yes	No	No
	Inter-nesting - 356		No	-	Yes	No	No
	Mating – 1,005		No	-	Yes	No	No
	Migration corridor – 1,005		No	-	Yes	No	No
	Aggregation – 1,114		No	-	Yes	No	No
Green turtle	Nesting - 23		Yes	No	Yes	Yes	No
	Foraging - 43		Yes	-	Yes	Yes	No
	Inter-nesting buffer - 121		Yes	-	Yes	No	No
	Inter-nesting - 169		Yes	-	Yes	No	No
	Mating - 174		Yes	-	Yes	No	No
	Migration corridor - 1,005		No	-	Yes	No	No

	Aggregation – 1,114		No	-	Yes	No	No
	Basking – 1,130		No	-	Yes	No	No
Hawksbill turtle	Foraging - 141		Yes	-	Yes	No	No
	Inter-nesting buffer - 150		Yes	-	Yes	No	No
	Nesting - 169		Yes	No	Yes	No	No
	Nesting - 971		Yes	No	Yes	No	No
	Mating – 1,005		No	-	Yes	No	No
	Migration corridor – 1,005		No	-	Yes	No	No
	Inter-nesting – 1,005		No	-	Yes	No	No
Loggerhead turtle	Foraging - 344		Yes	-	Yes	No	No
	Inter-nesting buffer - 986		Yes	-	Yes	No	No
	Nesting – 1,008		Yes	No	Yes	No	No
	Nesting – 1,285		Yes	No	Yes	No	No
	Inter-nesting – 1,688		Yes	-	Yes	No	No
Olive ridley turtle	Nesting – critical habitat - 177		No	No	No	No	No
	Foraging - 344		Yes	-	Yes	No	No
Whale shark	Foraging - 33		Yes	-	Yes	No	No
	Foraging (high prey density) – 1,329		No	-	Yes	No	No
Dwarf sawfish	Foraging - 203		No	-	Yes	No	No
	Nursing - 416		No	-	Yes	No	No
Freshwater sawfish	Pupping - 416		No	-	Yes	No	No
	Foraging - 416		No	-	Yes	No	No
	Nursing - 433		No	-	Yes	No	No
Green sawfish	Foraging - 203		No	-	Yes	No	No
	Pupping - 454		No	-	Yes	No	No
	Nursing - 769		No	-	Yes	No	No
Red-footed booby	Breeding - 59		Yes	No	Yes	Yes	No

Greater frigatebird	Breeding - 59		Yes	No	Yes	Yes	No
Lesser frigatebird	Breeding - 60		Yes	No	Yes	Yes	No
Wedge-tailed shearwater	Breeding - 61		Yes	No	Yes	Yes	No
	Foraging (in high numbers) – 1,741		No	-	No	No	No
White-tailed tropicbird	Breeding - 68		Yes	No	Yes	Yes	No
Brown booby	Breeding - 118		Yes	No	Yes	No	No
Lesser crested tern	Breeding - 141		Yes	No	Yes	No	No
Little tern	Resting - 142		Yes	No	Yes	No	No
	Breeding - 245		No	No	Yes	No	No
Roseate tern	Breeding - 142		Yes	No	Yes	No	No
	Resting - 571		No	No	No	No	No
Fairy tern	Breeding - 991		No	No	Yes	No	No
Bridled tern	Foraging (in high numbers) – 1,747		No	-	No	No	No
Sooty tern	Foraging – 1,772		No	-	No	No	No
Little shearwater	Foraging (in high numbers) – 1,826		No	-	No	No	No
White-faced storm petrel	Foraging (in high numbers) – 1,837		No	-	No	No	No
World Heritage Properties							
Ningaloo Coast	1,283	Section 7.3.1.1	No	No	Yes	No	No
Shark Bay	1,651		No	No	No	No	No
Commonwealth Heritage Places							
Scott Reef and surrounds	155	Section 7.3.1.2	Yes	No	Yes	No	No
Ashmore Reef National Nature Reserve	162		Yes	No	Yes	No	No
Mermaid Reef – Rowley Shoals	535		No	-	Yes	No	No
Ningaloo Marine Area - Commonwealth Waters	1,304		No	-	Yes	No	No
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,877		No	-	No	No	No
National Heritage Places							
The West Kimberley	1,283	Section 7.3.1.3	Yes	No	Yes	No	No
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves	1,651		No	No	Yes	No	No

The Ningaloo Coast	1,877		No	No	Yes	No	No
Shark Bay, Western Australia	1,283		No	No	No	No	No
HMAS Sydney II and HSK Kormoran Shipwreck Sites	1,651		No	-	No	No	No
Underwater Cultural Heritage							
TBA		Section 7.3.1.5	No	-	Yes	No	No
Marine Protected Areas							
Commonwealth							
Kimberley	111	Section 7.3.2	Yes	-	Yes	No	No
Cartier Island	134		Yes	-	Yes	No	No
Ashmore Reef	162		Yes	-	Yes	No	No
Oceanic Shoals	321		Yes	-	Yes	No	No
Argo-Rowley Terrace	323		No	-		No	No
Roebuck	480		No	-		No	No
Mermaid Reef	523		No	-		No	No
Joseph Bonaparte Gulf	604		No	-		No	No
Eighty Mile Beach	788		No	-		No	No
Dampier	950		No	-		No	No
Montebello	1,047		No	-		No	No
Gascoyne	1,277		No	-		No	No
Ningaloo	1,304		No	-		No	No
Shark Bay	1,588		No	-		No	No
Abrolhos	1,781		No	-		No	No
State							
Lalang-garram / Camden Sound	182	Section 7.3.2	No	-		No	No
North Kimberley	188		No	-		No	No
Rowley Shoals	567		No	-		No	No
Eighty Mile Beach Marine Park	612		No	-		No	No
Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area	1,097		No	-		No	No
Muiron Islands Marine Management Area and Ningaloo Marine Park	1,283		No	-		No	No
Shark Bay Marine Park	1,691		No	-		No	No
Fisheries							
Commonwealth Fisheries							
North-west slope trawl fishery	0	Section 7.3.3.3	Yes	-	Yes	Yes	Yes
Southern bluefin tuna fishery	0		Yes	-	Yes	Yes	Yes
Western tuna and billfish fishery	0		Yes	-	Yes	Yes	Yes

Skipjack fishery	0		Yes	-	Yes	Yes	Yes
Northern prawn fishery	395		Yes	-	Yes	No	No
Western deepwater trawl fishery	1,072		No	-	Yes	No	No
WA State Fisheries							
Mackerel Fishery	0	Section 7.3.4.4	Yes	-	Yes	Yes	Yes
West Coast Deep Sea Crustacean	0		Yes	-	Yes	Yes	Yes
South West Coast Salmon	0		Yes	-	Yes	Yes	Yes
Northern Demersal Scalefish	0		Yes	-	Yes	Yes	Yes
Marine Aquarium and Specimen Shell	28		Yes	-	Yes	No	No
Abalone	28		Yes	-	Yes	No	No
Broome Prawn	28		Yes	-	Yes	No	No
Kimberley Prawn	47		Yes	-	Yes	No	No
Kimberley Gillnet and Barramundi	213		No	-	Yes	No	No
Pilbara Trap	477		No	-	Yes	No	No
Pilbara Fish Trawl	560		No	-	Yes	No	No
Nickol Bay Prawn	560		No	-	Yes	No	No
Onslow Prawn	920		No	-	Yes	No	No
Exmouth Gulf Prawn	1,263		No	-	Yes	No	No
West Coast Rock Lobster	1,272		No	-	Yes	No	No
Gascoyne Demersal Scalefish	1,470		No	-	Yes	No	No
Shark Bay Scallop	1,512		No	-	No	No	No
Shark Bay Prawn	1,512		No	-	No	No	No
Shark Bay Crab	1,670		No	-	No	No	No
Shark Bay Beach Seine and Mesh Net	1,685		No	-	No	No	No
West Coast Demersal Scalefish	1,765		No	-	No	No	No
Northern Territory Fisheries							
Offshore Net and Line Fishery	537	Section 7.3.3.5	No	-	Yes	No	No
Spanish Mackerel Fishery	537		No	-	Yes	No	No
Demersal Fishery	540		No	-	Yes	No	No
Timor Reef Fishery	569		No	-	Yes	No	No
Coastal Line Fishery	618		No	-	No	No	No
Indonesian and Timor-Leste Coastlines							
Indonesia and Timor-Leste	>300	Section 7.3.7	Yes	-	Yes	No	No
Oil and Gas Industry							
INPEX Inchys FPSO	17	Section 7.3.8	Yes	-	Yes	Yes	No
Crux Platform (Future)	160		Yes	-	Yes	No	No

Montara FPSO	188		Yes	-	Yes	No	No

Physical Environment

Water Quality

Figure 9-23 presents the environmental fate of the modelled 80-day subsurface release of 254,400 m^3 of Prelude well fluids. The figure indicates approximately 10% of the hydrocarbon volume will evaporate to air, less than 2% or 5,000 m^3 forming a surface slick over a large area, more than 80% of the hydrocarbon (200,000 m^3) will decay within 100 days from the outset of the release with entrained and dissolved hydrocarbons in the water column peaking at the end of the 80-day period (approximately 40% of the total released volume) then reducing to 16% of the total hydrocarbon volume released within 20 days after spill cessation.

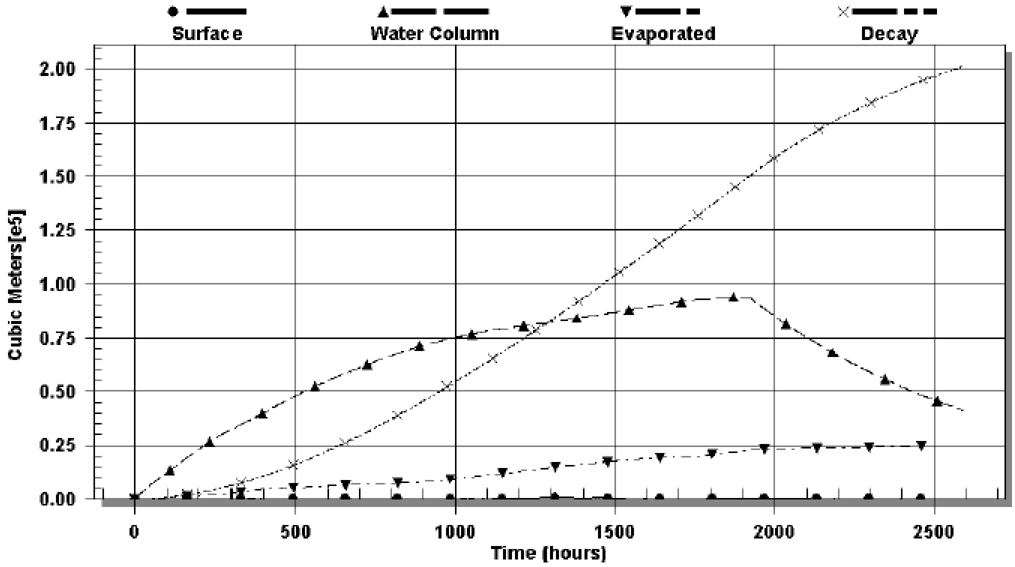

Figure 9-23: Predictions for the partitioning of oil mass over time through weathering processes for a subsea blowout of Prelude condensate for 80 days (1,600,000 bbl) (APASA, 2013)

The low residual volumes of floating oil will continue to weather, decay and diminish through further partitioning between the water column, air and shore/ sediment accumulation. The dissolved hydrocarbon fraction will have the greatest impact on water quality due to the presence of compounds such as BTEX and PAHs, which are known to be toxic to marine biota (refer to Biological Environment section below for a discussion of these effects). BTEX compounds are not expected to persist in the marine environment due to their volatility and will continually diminish due to weathering and biodegradation once released into the environment. PAHs are less volatile than BTEX due to their higher molecular weight/ more complex structures and are expected to persist for longer. The concentrations of hydrocarbons in the water column will decrease over time once the release has stopped due to processes such as dispersion, dilution, physical and biological degradation, and evaporation. For short duration release scenarios (i.e. diesel, HFO and condensate), these processes will begin to reduce the total amount of hydrocarbons in the water column shortly after the release.

MEG and amine spills may also adversely affect water quality to an extent. The MEG PNEC of 859 mg/L was modelled to be contained within an 8 km distance from the release location. MEG is readily biodegradable and its concentration will reduce significantly within days of the release. Refer to Section 9.9.2 for further impact assessment on MEG in the marine environment.

Amine will affect a larger area than a MEG spill due to its impact threshold of 1.8mg/L, which is forecast to extend over 78 km to the northeast and over 70 km to the southwest. The product exhibits readily to inherent biodegradability and is not anticipated to bioaccumulate and therefore is not persistent in the marine environment (Nalco Champion n.d).

Sediment Quality (Subsurface)

Sediment quality is not expected to be significantly affected by any of the worst-case scenarios that release hydrocarbons at the sea surface. Hydrocarbon contaminants (e.g. PAHs) from such surface releases are unlikely to reach the seabed due to the water depth and low natural sedimentation rates in the region. Hydrocarbon contaminants from the worst case subsea releases (loss of well control) may contaminate sediments by advective transport of the plume that will be formed during the release (Romero et al. 2015). This is considered likely to occur for the loss of well containment scenario due to the relatively long duration of the release. Any resulting contamination will be concentrated around, and down-current from the wellhead. Due to the low density and volatile nature of the hydrocarbon, weathered condensate is unlikely to be deposited to the seabed. The diesel and HFO releases from a loss of fuel from a vessel scenario have relatively low portions of volatiles, which are expected to evaporate quickly following the release. The remaining diesel and HFO fractions may sink to the seabed if exposed to considerable sedimentary particles, however this is considered very unlikely to occur in the open sea due to the low density of the residual hydrocarbons relative to seawater and the naturally low suspended solids and associated sedimentation rates. Residual diesel and heavy fuel oils near shorelines may be exposed to higher sediment loads and be more likely to sink. Stranding of residual/persistent oils on shorelines may lead to long-term contamination of sediments with high-molecular weight hydrocarbons. These compounds are typically much less toxic than low-molecular weight hydrocarbons.

The surface releases of amine and MEG are not considered likely to affect sediment quality due to the low inherent natural suspended solids, low sedimendation rates and the properties of the amine and MEG constituents, which are reported to have low organic carbon-water partition coefficient, KOC, indicating low adhesion/ high mobility of those chemicals in sediments (NLM Toxnet Database). Additionally the amine plume will be buoyant due to lower density relative to sweater so it will remain in the surface layers of the water column.

Air Quality

The gas plume from the worst-case loss of well containment scenario will result in a gas cloud upon reaching the water surface. This potentially large gas cloud is expected to disperse rapidly in the open, offshore environment. The formation of gas clouds can pose a significant safety risk from the formation of explosive mixtures and asphyxiation. Given the localised extent and open environment, this risk is considered to be very low for the receiving environment.

The table below presents the risk assessment for the worst case in terms of impacts emergency event (i.e. well LOC) for the physical environment, based on the worst case outcome for any environmental receptor (i.e. water quality).

Environmental Receptor	Consequence	Likelihood	Residual Risk
Physical Environment (Water, Sediment and Air Quality)	Massive	B-Remote	**Yellow**

Biological Environment

Benthic Communities

Bare Sediments

Seabed releases of Prelude well fluids may result in impacts to water quality and sediments in the vicinity of the release location (refer to sections Water Quality and Sediment Quality above). The seabed in the Operational Area and surrounds is characterised by bare sediments which host low density infaunal and epibenthic communities of filter feeding and deposit feeding organisms. These fauna species may be subject to acute and chronic toxic effects from exposure to hydrocarbons, however the extent of the affected habitat is expected to be localised to the vicinity of the release location. This bare sediment habitat is widely represented in the Timor Sea, and the associated fauna assemblages are not considered to be particularly sensitive or of high conservation value. Filter feeding benthic communities may be vulnerable to entrained and dissolved hydrocarbons. Entrained hydrocarbons can be ingested by filter feeders, leading to increased exposure due to accumulation of ingested oil droplets (Payne and Driskell 2003). While typically less toxic than dissolved hydrocarbons, entrained oil may still cause toxic effects and may also result in physical impacts such as clogging of filter feeding organs, potentially resulting in reduced feeding efficiency. Filter feeder, and sessile organisms in general, may be exposed to concentrations of dissolved hydrocarbons that result in acute and chronic toxic effects.

The more diverse benthic communities in the ZPI are found in shallower waters (< 50 m depth) or in association with islands, shoals, reefs, banks and the shoreline of the Australian, Indonesian and Timor-Leste mainlands. This diversity is due to ambient conditions supporting a healthy presence of primary producers, such as zooxanthellate corals, macroalgae and seagrasses and mangroves.

Modelling results from the loss of well containment, condensate, diesel and HFO scenarios indicate that several offshore reefs and islands, banks and shoals, may be contacted by hydrocarbons above adverse impact thresholds. Impacts on the primary producer communities in these locations are discussed below.

Corals

Experimental studies and field observations in the aftermath of hydrocarbon spills for corals indicate contact with hydrocarbons may result in impacts from no observable injury through to complete or partial tissue death of the colony, with tissue death occurring on the coral colony's surface where oil has adhered (Johannes et al., 1972, Jackson et al., 1989). Branching corals appear to be more sensitive to contact with hydrocarbons than other species and growth forms (Johannes et al., 1972), however, these are uncommon on intertidal reef flats and generally occur only in significant abundance subtidally.

Subtidal corals avoid direct contact with surface oil slicks but can be exposed to the entrained and dissolved hydrocarbon plumes when at the same depths. These hydrocarbon fractions are most likely to cause sublethal effects, such as polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduction in growth rates and impaired reproduction (Negri and Heyward, 2000). The planktonic stages (spawned gametes and larvae) of coral are more susceptible to adverse effects from exposure to hydrocarbons because of their tendency to float or remain near the water surface thus bringing them into direct contact with surface slicks (Villanueva et al., 2008). In addition, the concentrations of water-soluble fractions that inhibit fertilisation or are lethal to coral gametes are lower than those for lethal or sublethal effects in adult colonies (Heyward et al., 1994; Negri and Heyward, 2000). Coral planktonic stages of mass spawning species are largely confined to a 1 to 3-week period after spawning which generally occurs in March/ April but may occur twice a year for the coral colonies in the Timor sea. A spill outside of these periods is of less concern for coral planktonic stages.

Compared to subtidal coral habitats, reef flat communities generally have the lowest coral cover and lowest diversity of corals due to the harsh conditions for coral growth i.e. regular tidal exposure and extensive wave action (particularly along the west coast of Australia). As hydrocarbon ultimately floats to the sea surface, the most vulnerable coral colonies to direct contact with hydrocarbon spills are intertidal corals found on a reef flat, which are periodically exposed during low tides. As such, whilst the reef flat habitat is the most vulnerable coral habitat to direct contact to spills, it is also regarded as the least sensitive of the shallow coral habitats.

The intertidal and shallow water coral reef species at Browse Island, Heywood and Echuca Shoals and other nearby reefs and shoals could potentially suffer sub-lethal stress and, depending on the exposure time and concentration, potentially high rates of mortality. The exposure time and concentration are a function of the location, including the distribution of entrained and dissolved hydrocarbons throughout the water column, the extent of the spill, the met-ocean conditions at the outset of the spill and in the days and weeks following it. The extent of sub-lethal stress and mortality on coral species is likely to be species and depth dependent with intertidal and shallow subtidal species most likely to be impacted by hydrocarbon exposure, compared to their deeper counterparts. These shallow water communities have shown that they can recover quickly from natural mass mortality events. However, depending on the severity of the spill, recovery may still take years.

Macroalgae and Seagrass

Although seagrass and macroalgae may be subject to lethal or sublethal toxic effects including mortality, reduced growth rates and impacts to seagrass flowering, several studies have indicated rapid recovery rates may occur even in cases of heavy oiling (Burns et al.; Dean et al., cited in WEL, 2011).

Most seagrasses within the area that may be affected by the worst-case hydrocarbon spill scenarios are subtidal, although there may be relatively small areas of intertidal seagrasses along the WA coastline. Seagrass in the subtidal and intertidal zones will have different degrees of exposure to hydrocarbon spills. Subtidal seagrass is unlikely to be exposed to surface spilled hydrocarbons, as most hydrocarbons in subtidal environments will be concentrated at the surface. Intertidal seagrasses are vulnerable to smothering by floating oil slicks, which can lead to mortality if it coats their flowers, leaves and stems (Dean et al. 1998; Taylor and Rasheed 2011). Long-term impacts to seagrass are unlikely unless hydrocarbon is retained within the seagrass meadow for a sustained duration (Wilson and Ralph 2011). Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al. 2010). The potential for toxic effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs.

Like seagrasses, the potential impacts to macroalgae depend on the exposure pathway; most macroalgae in the region are subtidal, although intertidal macroalgae may be present. Studies of subtidal macroalgal assemblages exposed to fuel oil spills have shown that impacts from exposure are slight (Edgar et al. 2002; Lobón et al. 2008). Effects of exposure to oil on intertidal macroalgae are more variable; some studies reported little evidence of impacts (Díez et al. 2009), while others show significant impacts (De Vogelaere and Foster 1994). Recovery of intertidal macroalgae has been shown to occur faster in areas where oil has been left to degrade naturally compared to areas subject to intensive clean-up operations (De Vogelaere and Foster 1994). The same applies to the amine spills from the facility which were predicted to reach the closest sensitive receptors in only 2% of the cases above the defined impact threshold.

Mangroves

Intertidal mangrove habitats occur throughout much of Kimberley, offshore islands, Indonesia and Timor Leste and are highly susceptible to oil pollution (NOAA 2014). Given the distance between potential release locations and the nearest mangroves, any spilled hydrocarbons reaching mangroves will be highly weathered. Mangroves are vulnerable to contact with floating hydrocarbons, which may coat prop roots and pneumatophores (aerial roots that support oxygen uptake) (Duke and Archibald 2016). Exposure can result in direct effects such as yellowed leaves, defoliation and mortality, and indirect effects such as reduced recruitment and increased sensitivity to other stressors (NOAA 2014). Like seagrasses, mangroves can also be impacted by entrained and dissolved aromatic hydrocarbons either in the water or sediment.

Mangrove communities will not be impacted by the worst case modelled chemical spills from Prelude due to the large separation distance, dilution and low toxicity and low persistence of MEG and amine's low toxicity.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events (i.e. well LOC, diesel or HFO) for benthic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	**Consequence**	**Likelihood**	**Residual Risk**
Benthic Communities (Bare Sediments, Corals, Macroalgae and Seagrass and Mangroves)	Major	B-Remote	**Yellow**

Pelagic Communities (Plankton, Pelagic Fish and Invertebrates)

Plankton

Potential impacts to phytoplankton and zooplankton from the worst-case hydrocarbon or chemical spills are expected to consist of short-term acute toxic effects. Planktonic communities are characterised by relatively rapid turnover rates of short-lived biota. The high turnover rate will lead to rapid recovery as the spilled hydrocarbons decay in the environment. Within plankton communities, there is evidence from laboratory studies that some taxonomic groups, particularly zooplankton (e.g. copepods) may be more sensitive to hydrocarbon pollution (Almeda et al. 2013; Jiang et al. 2010). Few reliable studies have shown any impacts of hydrocarbon spills on planktonic communities, with most studies concluding that impacts from hydrocarbon pollution cannot be distinguished from natural variability (Abbriano et al. 2011; Davenport et al. 1982; Varela et al. 2006). Many marine species have planktonic larval phases (e.g. corals, many species of fish). Organisms with planktonic larval phases typically produce very high numbers of larvae. A worst-case credible spill may result in increased mortality of planktonic larvae (which are subject to high natural mortality); however, this is not expected to result in population, habitat or species scale impacts.

Pelagic Fish

Fish respire through gills, which may make them more vulnerable to dissolved hydrocarbons than fauna with less permeable skins, such as cetaceans, marine reptiles and birds. Despite this apparent vulnerability, fish mortalities are rarely observed to occur due to hydrocarbon spills (Fodrie and Heck 2011; International Tanker Owners Pollution Federation 2011b), although recorded instances of fish mortality from spills in confined areas (e.g. bays) exist. These observations are consistent with fish moving away from hydrocarbons in the water (Hjermann et al. 2007). Stochastic modelling results for all surface spills indicated that hydrocarbons are likely to be concentrated in surface layers. As a result, demersal fish are unlikely to be directly affected unless near a subsea release, as they are typically concentrated around seabed features e.g. shoals, banks and subea KEFs. Pelagic fish are more likely to encounter dissolved and entrained hydrocarbons above adverse exposure thresholds but may move away from affected areas following detection.

Exposure of fish to hydrocarbons may results in acute and chronic effects and may vary depending on a range of factors such as exposure duration and concentration, life history stage, inter-species differences and other environmental stressors (Westera and Babcock 2016). Early life history stages of fish (planktonic eggs and larvae) may be more vulnerable to hydrocarbon pollution than juvenile and adults, as these early life history phases cannot actively avoid water with high concentrations of hydrocarbons. Fish embryos and larvae may exhibit genetic and developmental abnormalities from long-term exposure to low concentrations of hydrocarbons (Fodrie and Heck 2011), although such long exposures may not be representative of real-world conditions. Exposures to PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen et al. 2017). Given the temporal and spatial scale of the worst-case credible spill scenarios (as shown by a single deterministic run), and the typically high supply of eggs and larvae, it is unlikely that any of the worst-case credible spill scenarios will result in significantly reduced recruitment of fish due to impacts during early life history phases.

Environmental monitoring of pelagic and demersal fishes immediately following the Montara oil spill indicated that despite the exposure to hydrocarbons, no adverse effects were detected in fish (Gagnon and Rawson 2012, 2011). Further sampling and testing over time indicated that fish captured in close proximity to the Montara wellhead were comparable to those collected from reference sites (Gagnon and Rawson 2012, 2011). This conclusion is supported by studies of fish stocks following large-scale hydrocarbon spills, which have shown relatively little evidence of reduced recruitment at the scale of fish stocks/populations (Fodrie and Heck 2011).

MEG or amine spills will also have transient effects on water quality and as such are not expected to adversely affect local fish communities at the population level.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for pelagic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Pelagic Communities (Plankton, Pelagic Fish and Invertebrates)	Moderate	B - Remote	Dark Blue

Key Ecological Features (KEFs)

Modelling study results indicated no KEFs will be exposed to adverse impact thresholds for floating hydrocarbons, but several KEFs may be exposed to entrained and dissolved hydrocarbons above adverse impact thresholds. KEFs with the closest proximity to the credible spill sources that may experience contact above moderate impact thresholds include (see Table 9-70):

- continental slope demersal fish communities
- ancient coastline at 125 m depth contour
- Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex
- Ashmore Reef and Cartier Islands and surrounding Commonwealth waters.

The continental slope demersal fish communities and the ancient coastline at 125 m depth contour are entirely sub-tidal. The relatively diverse benthic communities associated with these habitats, such as filter feeding communities and demersal fish assemblages may be impacted by dissolved and entrained hydrocarbon above moderate exposure thresholds, which may result in acute or chronic toxic effects. KEFs are most likely to be contacted by the subsea loss of well control scenario, due to the large entrained hydrocarbon fraction. Modelling results indicated that no single deterministic run affected the entirety of a sub-tidal KEF; most runs typically affected a minor portion of any given KEF. Given the nature of the KEFs and the scale of potential impacts, recovery of impacted parts of a KEF are expected to be facilitated by movement and recruitment of biota from the unaffected areas.

Several offshore reefs and islands within KEFs were identified by the modelling study results as potentially being contacted by hydrocarbons above adverse exposure thresholds. These include Ashmore Reef and Cartier Island and Seringapatam Reef and Commonwealth waters in the Scott Reef complex. Offshore reefs and islands typically host light-dependent ecosystems characterised by benthic primary producers and biological communities that are distinct from coastal islands and the mainland. Potential impacts will be limited to submerged receptors only as floating oils were predicted to contact any of these KEFs at concentrations well below the lower adverse impact threshold at very low annual probabilities between 0.5% and 3%. Environmental effects will be similar to those described for sub-tidal KEFs.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for pelagic communities, based on the worst-case outcome for any of the environmental receptors in this group.

Environmental Receptor	Consequence	Likelihood	Residual Risk
KEFs	Major	B-Remote	Yellow

Threatened and Migratory Species

Cetaceans and Dugongs

Marine mammals potentially present, their conservation status and any associated BIAs within the ZPI are detailed in Section 7.2.8.

Cetaceans exposed to surface, entrained or dissolved aromatic hydrocarbons above adverse exposure thresholds may suffer external oiling, ingestion of oil and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Cetaceans in coastal waters (e.g. coastal dolphin species and humpback whales at the northern limit of their migration) are at lower risk of impacts than cetaceans in offshore water due to the oil weathering before reaching coastal waters.

Skin contact with floating hydrocarbons could result in irritation and absorption and potential for impact to eyes and airways. Inhalation of vapours or the ingestion of hydrocarbons can potentially have lethal effects due to damage to the whale's respiratory and nervous systems. Baleen whales, such as blue whales and humpback whales, are the most likely to be susceptible to hydrocarbon ingestion due to their feeding through baleen plates including from near water surface. Toothed whales and dolphins are less susceptible due to their 'gulp' feeding approach, often targeting individual specific prey away from the sea surface (Woodside Energy Limited 2011).

However, cetaceans and dugongs are highly mobile, capable of long migrations, and typically in low numbers/densities in the moderate exposure zone. Experimental and field observations indicate that whales and dolphins may be able to detect and actively avoid hydrocarbon slicks, but this may not always be possible and exposure to floating oil may still occur (Smith et al. 1983, Geraci and St. Aubin 1990).

Vessel-based surveys of the Browse Basin area by the Centre for Whale Research (Western Australia) Inc. between June and November 2008 recorded low numbers of cetaceans in a broad survey area, with average densities of 0.00013 large cetaceans (whales) per square kilometre (1 whale per 7,700 km^2) and 0.026 small cetaceans (dolphins) per square kilometre, or 1 cetacean in 39 km^2 (Jenner, Jenner & Pirzl 2009, cited in INPEX 2010). Given such sparse distributions, it is not anticipated that impacts to a significant portion of the cetacean and other mammal populations would result if a spill was to occur.

Dugongs are known to occur in coastal waters and around offshore islands within the moderate exposure zones identified by the stochastic spill modelling. There is a paucity of studies examining the effects of hydrocarbon spills on dugongs, although the direct impacts of exposure to hydrocarbons may be similar to cetaceans. Like cetaceans, dugongs are expected to be resilient to direct impacts due to their thick skin and blubber. Suitable dugong habitat is associated with seagrass meadows, which are typically restricted to shallow waters around the mainland coast and islands. The distance of dugong habitat from the worst-case credible spill release locations means that oil reaching dugong habitat will be highly weathered.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for cetaceans and dugongs.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Cetaceans and Dugongs	Moderate	B-Remote	Dark Blue

Reptiles

Stochastic modelling results indicated moderate exposure zones overlap the known distribution of several species of marine turtles and sea snakes. Saltwater crocodiles were also identified as potentially occurring within the adverse exposure zone; given the preferred habitat for saltwater crocodiles are freshwater rivers and estuaries, impacts to this species from the worst-case hydrocarbon spills are not considered credible. Marine turtles may be exposed to floating hydrocarbons when at the sea surface (e.g. breathing, basking etc.), and are not expected to actively avoid floating hydrocarbon slicks (NOAA 2010). Exposure to floating or entrained hydrocarbons may result in external oiling, which could result in impacts such as inflammation or infection (Gagnon and Rawson 2010, Lutcavage et al. 1995; NOAA 2010). Given the large portion of non-persistent hydrocarbons in Prelude condensate and well fluids, the loss of diesel or heavy fuel oil scenarios are considered to pose the greatest risk of external oiling. Dissolved hydrocarbons may result in toxic effects on marine turtles, however their relatively impermeable skin reduces the potential for these impacts.

Stochastic modelling identified island and mainland shoreline habitats (sandy beaches and inter-nesting habitat) that may be exposed to hydrocarbons above moderate exposure thresholds. Some of these are classified as habitat critical for the survival of marine turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a) and BIAs as liasted in Table 7-5. Of these, the critical nesting and inter-nesting habitats for green turtles at Browse island have the highest probability to be affected above moderate impact thresholds.

Several shoals and banks occur in the ZPI, which may be used as foraging areas by marine turtles. Impacts to benthic habitats and biota at these shoals and banks may result in a reduction of prey for marine turtles. A spill reaching critical nesting habitats during peak periods to turtle nesting could result in impacts. With respect to floating oil, given the distance of these locations from Prelude, worst-case credible spills of Prelude well fluids, condensate, HFO or diesel reaching these areas will be highly weathered and unlikely to result in impacts from an acute toxicity perspective, except for Browse Island.

Sea snakes have similar exposure pathways to spilled hydrocarbons as marine turtles (although sea snakes will not be exposed to shoreline hydrocarbon accumulation). Potential impacts are expected to be comparable and may include irritation of eyes and mucous membranes. Sea snake mortality has been linked to exposure to hydrocarbon spills, with dead sea snakes recovered from the region of the Montara oil spill showing high levels of petroleum hydrocarbons (including PAHs) in the trachea, lungs and stomach (Gagnon 2009). These results are consistent with exposure through ingestion and respiration of hydrocarbons. Ashmore Reef and Hibernia Reef are noted as being one of the few sites where the critically endangered leaf-scaled sea snake and short-nosed sea snake have been recorded, along with other species of sea snake. Both the leaf-scaled and short-nosed sea snakes have not been detected at Ashmore Reef since 2001, despite increased biological survey effort. Both locations were identified by the stochastic modelling as potentially being exposed to hydrocarbon above moderate adverse exposure limits.

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for reptiles.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Reptiles	Major	B-Remote	**Yellow**

Seabirds and shorebirds

Seabirds and shorebirds are present in the ZPI (see Section 7.0 for details). Seabirds are particularly vulnerable to hydrocarbon spills owing to high potential for contact with the sea surface where they feed, rest or moult. Feeding by seabirds recorded in the region involves snatching prey items from or below the water surface by paddling or aerial diving, and these birds also rest on the ocean surface. Migrating and residential shorebirds by contrast are less susceptible to severe oiling and associated physical effects as they confine feeding to shorelines (Sholz et al. 1992; cited in Woodside Energy Limited 2011) and they do not land on the water surface. In cases where the hydrocarbon spill comes ashore large number of shorebirds may be impacted.

In the event of a spill, seabirds and shorebirds are likely to make contact with spilled hydrocarbons due to the amount of time they spend on or near the surface of the sea and on affected foreshores. Contact with hydrocarbon may impact a bird's ability to fly due to external and/ or internal exposure potentially leading to death by drowning, starvation or predation. Hydrocarbon contamination affects the feathers insulation, buoyancy and waterproofing properties and ultimately the bird's survival. The overriding behaviour of a bird with oiled feathers is preening to the exclusion of all other normal activities. As an affected bird preens, it ingests and inhales hydrocarbons, which can cause damage to internal organs such as the lungs, intestines and liver. Suppression of the immune system can also occur and other effects include impacts to reproductive success through decreased fertility of eggs and reduction in egg shell thickness.

Specifically, estimates for the minimal thickness of floating oil that might result in harm to seabirds through ingestion from preening of contaminated feathers, has been estimated by different researchers at approximately 10g/m^2 (French 2000) to 25g/m^2 (Koops et al. 2004).

The main area of sensitivity for migratory birds are the Ashmore Reef and Cartier Islands, which are recognised as particularly important for feeding migratory shore birds during non–breeding periods. These islands are an important staging point during the migration between the Northern Hemisphere and Australia. During October to November and March to April large flocks of birds protected under the JAMBA, CAMBA and ROKAMBA are more likely to be present in the area and sensitive to shoreline oil contact. Browse Island, and Seringapatam and Scott Reefs are recognised as important habitat for seabirds. These locations, as indicated by modelling, will not be affected to any adverse impact levels i.e. > 10g/m^2 (French 2000).

The table below presents the risk assessment for the worst-case in terms of impacts emergency events for seabirds and shorebirds.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Seabirds and shorebirds	Massive	B-Remote	Yellow

Socio-Economic and Cultural Environment

Commonwealth Heritage Places and Marine Protected Areas

Commonwealth Heritage Places and Marine Protected Areas overlap with the sensitive receptors discussed in the Physical and Biological Environment sections above.

Several offshore islands and reefs listed as Commonwealth Heritage Places were identified by the spill modelling results as potentially being contacted by hydrocarbons above moderate exposure thresholds. These include:

- Ashmore Reef National Nature Reserve Commonwealth Heritage Place
- Scott Reef and Surrounds Commonwealth Heritage Place
- Mermaid Reef – Rowley Shoals Commonwealth Heritage Place

The environmental values of these reefs are primarily their outstanding natural values. These have been discussed in the preceding sub-sections.

Modelling results of the worst-case credible spill scenarios indicated a range of Commonwealth, state and territory marine parks may be contacted above moderate exposure thresholds (Table 9-70). These parks contain a range of environmental values such as marine biota, representative marine habitats and unique sea scapes (e.g. KEFs). Environmental values for these marine parks are described in Section 7.0 and discussed above in Physical and Biological Environments. Refer to these sections for discussion of potential impacts to these environmental values within marine parks.

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Commonwealth Heritage Places and Marine Protected Areas	Massive	B-Remote	Yellow

Fishing Industry

A number of commercial fisheries operate within the moderate exposure zone determined from spill modelling results. The worst-case credible hydrocarbon spill scenarios may result in a range of impacts to commercial fishing activities, such as (International Tanker Owners Pollution Federation 2011b):

- displacement of fishing effort from areas affected by a spill or spill response activities
- damage to fish stocks due to mortality
- closure of fisheries by management agencies
- inability to sell catch due to perceived or actual fish tainting or contamination
- oiling of fishing gear, particularly by floating oil.

A significant hydrocarbon spill would likely result in the temporary closure of areas of fisheries within the area of moderate exposure. The spatial extent and duration of the closure would depend on the nature and scale of the pollution resulting from the hydrocarbon spill. Given the large spatial extent of managed fisheries relative to the area potentially contacted above moderate exposure thresholds for any single event, a spill is unlikely to result in the complete closure of a fishery. Rather, the closure of areas to fishing is more likely to result in the displacement of fishing effort during the response and recovery phases. Displacement from productive fishing areas may result in impacts to fishers such as increased costs and reduced catch per unit effort and reduced income. Exposure of fish to hydrocarbons may result in tainting, which may render landings unsuitable for human consumption. Tainting may occur even at low levels of hydrocarbon exposure. Monitoring of fish for taint immediately following capping of the Montara well detected differences between fish likely to have been exposed to hydrocarbons, however these differences were not conclusively linked to oil contamination and fell within the range of “normal” fish odours (Rawson et al. 2011). Samples collected at the same monitoring locations two and four months after were not distinguishable (Rawson et al. 2011). These results are consistent with other studies of fisheries resources exposed to hydrocarbon pollution, which acknowledge the potential for impacts to fisheries resources and have shown little potential risk for consumers if suitable fisheries management actions are undertaken (Law and Hellou 1999; Law and Kelly 2004). Fish caught in areas affected by a significant hydrocarbon spill may be perceived as being of poorer quality, even if no decrease in quality is evident. This may result in lower prices at the time of sale and subsequently lead to reduced income for commercial fishers.

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	**Consequence**	**Likelihood**	**Residual Risk**
Fishing Industry	Moderate	B-Remote	**Dark Blue**

Tourism and Recreation

There are currently no known tourism activities in the Operational Area, or immediate surrounding areas, due to the remoteness and water depth of the area. Some tourism activities may occur at the remote offshore islands and reefs within the ZPI. These activities are expected to be exclusively nature-based tourism and impacts to the environmental values associated with these islands and reefs may impact upon tourism activities. Mainland coastline and islands will typically host more nature-based tourist activities than offshore islands. This activity is expected to be seasonal, with increased visitation during the winter dry season months. Impacts to tourism activities are expected to be minor based on the likelihood and nature of contact to environmental values that support tourism activities. Impacts to these values may result in displacement of tourism activity, introduction of temporary exclusion zones or avoidance of areas with visible oil sheens, and a corresponding loss of revenue for tourist operators (e.g. charter fishing cancellations due to fishery closures).

The table below presents the risk assessment outcome for this receptor.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Tourism and Recreation	Minor	B-Remote	Dark Blue

Defence

Defence activities within the offshore North Australian Exercise Area (NAXA) are unlikely to be affected by the worst-case credible hydrocarbon spills. Activities may be temporary displaced from areas where spill response operations are underway. This would be highly localised and temporary in nature.

Shipping

Potential impacts to commercial shipping from the worst-case credible spill scenarios are expected to be slight and consist of temporary displacement of other users from areas where spill response activities are underway. These are expected to be concentrated around the release location.

The table below presents the risk assessment outcome for defence and shipping.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Defence and Shipping	Minor	B-Remote	Dark Blue

Oil and Gas Industry

Petroleum activities in the region include drilling and pre-installation activities for the future Shell-operated Crux facility, the INPEX-operated Ichthys facility and the Montara development. Other exploration activities are expected to occur in the Timor Sea throughout the life of the Prelude operations. Reduction in water quality as a result of a worst-case credible spill may affect the operation of these facilities if seawater at the facility is no longer suitable for intake (e.g. for use as cooling water or feed water for RO water generation). This may result in impacts to routine operations such as decreased production. A worst-case hydrocarbon spill response may result in competition for vessels and potentially drilling rigs (if well intervention or a relief well is required).

The table below presents the risk assessment outcome for the oil and gas industry.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Oil and Gas Industry	Minor	B-Remote	Dark Blue

Indonesian and Timor Leste Coastlines

The spill modelling results indicate there is the potential for the well loss of containment spill scenario resulting in contact with the Indonesian coastline. The probability of floating film contact with the Indonesian Coastline was estimated at < 0.5% and minimum arrival time of 64 days for those rare contact scenarios, with maximum local accumulation of 3 kg/m^2 for the worst replicate spill. Contact for entrained oil was also prediced at 33% for the moderate exposure threshold. The probability of dissolved hydrocarbon contact was predicted to be approx 5% for the moderate exposure threshold.

Given the relatively long time to contact, soluble aromatic hydrocarbon fractions are unlikely to be present, leaving relatively low toxicity residual hydrocarbons such as paraffins. Potential impacts may include smothering of coastal infrastructure (e.g. aquaculture, fishing equipment), which may result in localised economic impacts.

The table below presents the risk assessment for the worst case in terms of impacts emergency events for seabirds and shorebirds.

Environmental Receptor	Consequence	Likelihood	Residual Risk
Indonesian and Timor Leste Coastlines	Major	B-Remote	Yellow

9.13.5 Risk Assessment Summary

The risk assessment summary in Table 9-71 is based on the worst case in terms of consequences spill event, i.e. the loss of well control LOC.

Table 9-71: Emergency Events Evaluation of Residual Risks

Environmental Receptor	Consequence	Likelihood	Residual Risk
Evaluation – Unplanned Risks			
Physical Environment	Massive	B-Remote	Yellow
Biological Environment	Major	B-Remote	Yellow
Socio-economic Environment	Massive	B-Remote	Yellow

9.13.6 ALARP Assessment and Environmental Performance Standards

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Elimination	None identified	N/A	N/A	N/A	N/A	N/A
Substitution	Substitute MEG, Amine or HFO/IFO within MDO or LNG with less hazardous chemicals	No	MEG and amine (MDEA) have been selected based on their performance and non-hazardous HES properties. MEG is classified as PLONOR and is also considered as non-persistent in the environment and does not bioaccumulate. Amine (MDEA) is biodegradable and exhibits low toxicity. Additionally amine is used in closed systems and is not intended to be disposed to the marine environment. It is not practical for Shell to mandate vessel specifications or requirements regarding fueld types onboard offtake tankers visiting the Prelude FLNG facility.	N/A	N/A	N/A
Engineering	FLNG is double hulled	Yes	Prelude FLNG is double-hulled except for the area around the hull thrusters as purposefully designed. In addition, the condensate storage tanks are surrounded by ballast water tanks which provide additional protection in case of a hull breach.	N/A	N/A- Prelude FLNG is permanently installed (moored) and commissioned at the time this EP commenced, and is therefore not described in further detail here as an EPS	N/A
Engineering	Condensate offloading hoses have Marine Breakaway Coupling (MBC)	Yes	The MBC is designed to prevent oil spills and protect the transfer system from damage in the event of a tanker breakout or an excessive pressure surge.		Condensate offloading hose is equipped with a MBC	Records demonstrating presence of an MBC on the condensate offloading hose.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Engineering	Use of radars/ Automatic Identification System (AIS)/ Automatic Radar Plotting Aid (ARPA) and associated alarms on FLNG, infield support vessels and supply vessels	Yes	Use of radars/ Automatic Identification System (AIS)/ Automatic Radar Plotting Aid (ARPA) and associated alarms on FLNG, infield support vessels and supply vessels. This technology allows early identification and notification of approaching vessels and is crucial in minimising the risk of vessel-to-vessel collision. All product off-loading activities are done in accordance to the Prelude Terminal Information Book (OPS_GEN_004647) which includes specific collision prevention procedures and measures including: • Controlled speed for all marine vessels in the PSZ • Ability for three way communication between FLNG, infield support vessels and offtake vessel • The PSZ is patrolled by support vessels • FLNG radar/ ARPA and associated alarms monitored for approaching vessels • Vessels follow pre-determined access routes to the FLNG and assess environmental conditions (wind, current and sea state) • Contractual requirement for vessels to be manned by competent crew • All contracted vessels employed are subjected to a stringent assurance process, and • Product offtake tankers are assisted by Prelude infield support vessels and piloted by Prelude FLNG marine pilots to ensure safe berthing/ offloading/bunkering/ de-berthing.		Product offtake tankers are assisted by Prelude infield support vessels.	AIS information shows offtake tankers being assisted by Prelude infield support vessels.
					Product offtake tankers are piloted by competent marine pilots to ensure safe berthing/ offloading/ de-berthing.	Pilot Competency Assurance
					The FLNG supporting vessels are equipped with suitable and operational navigation and collision avoidance equipment, specifically: • ARPA • AIS • Radar, and/or • Equivalent system.	Marine Assurance records

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Exclusion zone around drill centre and FLNG	Yes	As per section 616 of the OPGGS Act, a PSZ is established for the Prelude FLNG, moorings and drill centre. The gazetted PSZ prohibits all vessels other than vessels under the control of Shell and those operated by authorised persons from entering or being present in the area of the PSZ without the consent in writing of NOPSEMA. This small area of this established zone in the open ocean environment is considered to be inconsequential to other marine users.	N/A	N/A - This is regulated control measure which is already in place.	
Administrative and Procedural Controls	FLNG and Vessel Bunkering Procedures for Hydrocarbons and Chemicals	Yes	The purpose of these procedures is to ensure that good practice and industry standards are applied during bunkering operations. Implementation of these procedures will minimise the risk of a spill incident through e.g. both facilities prepared for bunkering, drains plugged, approved bunker plan for specified volumes, designated receiving tanks and agreed pumping rates, direct communication between all involved and supervision at both ends and availability of spill kits onboard each vessel/facility.		The FLNG and contracted marine support vessels will have dry-break couplings, inspected and certified bunkering hoses, and this equipment will be maintained.	Assurance and maintenance records.
					No spills to water as a result of bunkering activities.	No incidents involving spills to water as a result of bunkering activities.
Administrative and Procedural Controls	SOPEP or SMPEP for Vessels	Yes	SOPEP shall be in place for all marine support vessels as required by class in accordance with As per AMSA Marine Order 91.	N/A	N/A to regulated requirements such as SOPEP	N/A
Administrative and Procedural Controls	Vessel anchoring and mooring plan	Yes	No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell.		No support vessel anchoring in the Operational Area except in emergency situations or under issuance of a specific permit by Shell.	Records verify no breaches of anchoring procedures in the Operational Area.

Hierarchy of Controls	Control Measure	Adopted?	Justification	EPS #	Environmental Performance Standard (EPS)	Measurement Criteria
Administrative and Procedural Controls	Subsea control operators are competent	Yes	Subsea control operators are trained and competent in the operation and monitoring of the hydrocarbon system.		Subsea control operators are competent in the operation and monitoring of the hydrocarbon system	Competency assurance records

A comprehensive assessment of the risks from the worst-case credible spill scenarios arising from Prelude Operations has been undertaken. Globally, Shell is experienced in the design, installation and decommissioning of similar developments and understands the impacts and risks that may arise from these worst case credible spill scenarios. Shell has undertaken environmental studies, numerical modelling and consultation to identify the environmental receptors that may be affected and understands the nature and implications of potential hydrocarbon pollution. These studies, along with Shell's organisational experience, allows a high degree of confidence to be placed in the outcomes of the assessment of the risks.

Principles of ESD

The risks and impacts from the worst-case credible spill scenarios are inherently inconsistent with some of the principles of ESD based on the following:

- environmental resources and sensitivities may be significantly impacted in the event a worst-case credible spill, and
- a worst-case credible spill may prevent others exercising their right to access environmental resources.

Shell will apply a range of controls to ensure that a worst-case credible spill from the Prelude project never occurs. These include a range of industry best practices that have been developed through extensive industry experience, including the lessons learned from significant unplanned releases such as the Macondo and Montara well blowouts. Following successful application of these controls, Shell considers the residual risk to be consistent with the principles of ESD. This consistency is achieved by:

- developing natural resources in an environmental responsible manner, resulting in income for government, generation of Australian jobs, and developing an increased understanding of the Timor Sea environment.
- application of the precautionary principle in the assessment of hydrocarbon spill scenarios by:
    - using worst-case credible spill scenarios. Industry statistics indicate the vast majority of unplanned spills are significantly smaller than the worst-case credible spills.
    - using a stochastic modelling approach for numerical modelling of the worst-case credible spill scenarios that includes a large number (hundreds) of deterministic runs covering a range of metocean conditions.
    - using environmentally conservative adverse exposure zone thresholds.

Relevant Requirements

Management of the impacts and risks from unplanned hydrocarbon spills are consistent with legislative requirements, including:

- compliance with international maritime conventions, including:
    - STCW Convention
    - SOLAS Convention
    - COLREGS
    - MARPOL: Annex I: prevention of pollution by oil and oily water.
- compliance with Australian legislation and requirements, including:

- Navigation Act 2012 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983:
  - Marine Order 21 (Safety of Navigation and Emergency Procedures
  - Marine Order 27 (Radio Equipment)
  - Marine Order 30 (Prevention of Collisions)
  - Marine Order 71 (Masters and Deck Officers)
  - Marine Order 91 (Marine pollution prevention – oil).
- OPGGS Act 2006 and OPGGS (E) Regulations:
  - accepted WOMPs for all well activities, including drilling, operation, suspension and abandonment
  - accepted EP and OPEP for all petroleum activities associated with the Prelude project.
- Implementation of recognised industry best practices, such as:
  - design, construction and operation of Prelude infrastructure in accordance with recognised industry standards
  - mutual aid agreement in place with other petroleum operators to assist with drilling rig availability for relief well drilling
  - agreements in place with oil spill response service providers
  - development of SIMOPS plans for activities that may interact with the Prelude FLNG facility.

Matters of National Environmental Significance

Commonwealth Marine Environment

Table 9-72 provides a summary of the alignment between managing of the emergency events aspect at Prelude with the relevant MNES acceptability considerations listed in EPBC Management Plans/Recovery Plans/Conservation Advices.

Table 9-72: Summary of Alignment of the Impacts from the Emergency Events associated with the Prelude Petroleum Activities to Relevant Requirements for MNES

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory Species – Marine Mammals Threatened and Migratory species - marine reptiles Threatened and Migratory species - sharks and rays	Emergency events due to loss of containment are not considered to be acceptable to Shell. In the event of such an incident, the relevant EPBC Management Plans, Recovery Plans and Conservation Advice documentation will be consulted based on the nature/scale of the spill and the determination of the potentially impacted environmental sensitivities to	Shell has identified the potential for hydrocarbon pollution, and potential consequential habitats degradation, from large-scale hydrocarbon releases as a significant environmental risk. Shell has applied a range of controls that are intended to reduce the likelihood of such a release occurring, and mitigative controls to understand

Matters of National Environmental Significance	MNES Acceptability Considerations (EPBC Management Plans/Recovery Plans/Conservation Advices)	Demonstration of Alignment as Relevant to the Project
Threatened and Migratory species - birds	ensure mitigation and recovery efforts are in alignment. Refer to Table 7-4 for full list of potential plans at the time of writing this EP. The relevant databases will be checked at the time to ensure currency and any relevant inclusions will be made.	and reduce the severity of impacts should such a release occur.
Commonwealth Marine Environmnent		

External Context

There have been no objections or claims raised by Relevant Persons to date around the emergency events aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of impacts.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The EPOs, controls and EPSs which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements. Shell has, and will continue to maintain, an appropriate spill response framework, which includes regular testing of the response arrangementsas per Section 10.7.

Acceptability Summary

The assessment of impacts and risks from the worst-case credible unplanned hydrocarbon spills determined the residual impact and risk rating is Yellow (Table 9-71). Given the significant consequence of the risks associated with these worst-case hydrocarbon spills, Shell has undertaken an extensive, conservative risk assessment and will apply a range of controls consistent with relevant requirements and industry best practice.

As outlined above, the acceptability of the impacts and risks from unplanned spills associated with Prelude operations has been considered in the context of:

- The established acceptability criteria for the emergency events aspect
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

Based on the points discussed above, Shell considered the impacts and risks from worst case Prelude emergency events to be acceptable following the application of the controls outlined in the ALARP Demonstration above.

9.13.7 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
No emergency events associated with the unplanned release of hydrocarbon or chemicals to the marine environment.	Incident reports associated with spills which initiated the ERT and/or IMT.

9.14 Oil Spill Response Strategies

9.14.1 Aspect Context

This section describes any new or unique environmental impacts or risks presented by implementation of the emergency events response strategies included in the OPEP (HSE_PRE_013075) which may be enacted to respond to hydrocarbon and chemical spills as described in Section 9.13. Where impacts and risks are already adequately addressed in the preceding sections of this EP, as indicated in Table 9-73, they are not discussed further in this section

Capability, readiness and implementation requirements for the specific spill response strategies are addressed in the OPEP (HSE_PRE_013075), which includes EPSs around the required performance of each response strategy, and hence are not repeated in this EP.

Typically environmental aspects, impacts and risks that arise from conducting the emergency response activities are similar to those already described in Section 9.3 to 9.12. for the planned and unplanned activities, particularly for vessel-based operations. Where additional impacts or risks exist for the identified aspects, these are described in the following subsection. Table 9-73 summarises the aspects generated by implementing the spill response activities and identifies any that are new or unique aspects for further assessment.

Table 9-73: Spill response strategies and associated environmental aspects identified for each including those that are considered new or unique

		Aspects Generated											
		Physical Presence	Lighting[2]	Noise Generated	Disturbance to Seabed	Disturbance to Ground[1]	Introduced Marine Pests	Discharge of Liquid Wastes	Planned Chemical Discharge[1]	Atmospheric Emissions	Greenhouse Gas Emissions	Waste Management	Emergency Events
Response Activities	Source Control (including SSDI)[3]	✓	✓	✓	✓		✓	✓	×	✓	✓	✓	✓
	Monitor and Evaluate	✓		✓			✓	✓		✓	✓	✓	✓
	Natural Recovery												
	Chemical Dispersant (Surface)	✓		✓			✓	✓	×	✓	✓	✓	✓
	Contain and Recover	✓		✓	✓		✓	×		✓	✓	✓	✓
	Protect and Deflect	✓		✓			✓	✓		✓	✓	✓	✓
	Shoreline Clean-up					×		✓		✓	✓	✓	
	Oiled Wildlife Response	✓		✓			✓	✓		✓	✓	✓	✓
	Scientific/ Oil Spill Monitoring	✓		✓			✓	✓		✓	✓	✓	✓

Notes:

✓ - The aspects and associated impacts and risks are already adequately addressed in the EP Sections 9.3-9.12.

× - There is an aspect of the response activity that may produde a new or unique impact/risk not already addressed in the EP.

1. New or different aspect not previously described in the EP
2. Due to daylight operations only for typical vessel-based activities (excluding source control), lighting impacts for stationary, non-operating vessels at sea during night will not present a credible impact to sensitive receptors.
3. As described further in the OPEP, source control to respond to a LoWC emergency event may include deploying a capping stack, drilling a relief well and/or use of the Offset Intallation Equipment (OIE) System. These activities will be managed in accordance with the accepted OPEP, Safety Case and WOMP.

9.15.1.1 Subsea (Source Control) and Surface Dispersant Application

Dispersants are applied to hydrocarbon spills to enhance the breakdown of hydrocarbon droplets and enhance dispersion into the water column to:

- Break up floating oil and reduce floating oil concentrations, thereby reducing the exposure of seabirds and surfacing marine fauna to hydrocarbons
- Reduces the size of the entrapped oil droplets further aiding dispersion and enhancing biodegradation.

Additionally, source control is the primary response strategy for the well loss of containment scenario and is aimed at stopping the flow of well fluids to the environment. Subsea Dispersant Injection (SSDI) may be required as part of the overall source control strategy to ensure conditions are safe for responders (i.e. minimise gas cloud concentration and extent) to enable installation of a capping stack, relief well drilling and/or application of the OIE.

9.15.1.2 Contain and Recover - Decanting Operations

Application of the Contain and Recover strategy is significantly limited by weather, logistics, and requires substantial temporary waste storage for recovered hydrocarbons. Recovered hydrocarbons will inevitably contain a large proportion of water in addition to recovered oil that may need to be decanted back to the sea to optimise the recovered oil fraction. Refer to the OPEP for further details.

9.15.1.3 Shoreline Cleanup – Disturbance to Ground

Conducting shoreline protection and clean-up involves moving personnel and equipment, which includes the environmental aspect of ground disturbance. The objective of shoreline clean-up is to apply clean-up techniques that are appropriate to the shoreline type to remove as much oil as possible where there is a net environmental benefit in doing so. Various techniques may be used alone or in combination to clean up oiled shorelines, including Shoreline Clean-up Assessment Technique (SCAT), natural recovery, absorbents, sediment reworking, manual and mechanical removal and washing, flooding, and flushing. Considerations for selecting and implementing shoreline clean-up techniques are included in the OPEP.

9.14.2 Description and Evaluation of Impacts

Subsea and Surface Dispersant Application

Environmental effects associated with dispersant application include:

- Increase in the mass of entrained hydrocarbons with smaller droplet sizes affecting larger areas and being bioavailable for injestion by some oceanic and benthic organisms (e.g. fish, plankton). The effects of entrained hydrocarbons on sensivite environmental receptors are discussed in Section 9.13.4.
- Temporary reduction in water quality and exposure of marine biota to dispersant chemical's inherent ecotoxicity, biodegradability and bioaccumulation properties. The level of toxicity varies amongst the different dispersant types and can result in increased in-water concentrations of the toxic components of hydrocarbons. Dispersant combined with dispersed oil can be acutely toxic in the water column at specific concentration thresholds, and is noted for its toxicity to habitats such as corals, seagrass, and macroalgae.

The extent of these impacts will also depend on the chemical dispersant type and dose rates, and external conditions (time of the year, weather and sea conditions, proximity of sensitive receptors and their life stage, etc.). These impacts will provide another consideration into the decision process on strategy selection (SIMA) and timing on a case-by-case basis at the time of the incident as described in the OPEP.

Sensitive reef communities are located within the Browse Basin, with the closest being around Browse Island, Echuca and Heywood Shoals and Ashmore and Cartier Islands, while seagrass meadows are located in some of these areas also. If applied appropriately, dispersants can provide a net environmental benefit by limiting exposure of an oil spill to high environmental value sensitive receptors. Elevated concentrations of dispersant are generally localised and of short duration, with dilution and dissipation being relatively rapid after application. Therefore, residual impacts from the use of dispersants are expected to low in nature and scale when assessed in isolation compared to the impact of the spill without dispersant application, and ranked as minor impact consequence (Magnitude -2, Sensitivity M).

Decanting Operations

In order to optimise recovery of floating hydrocarbon removed from the sea surface during Contain and Recover operations, it may be required to decant some of the oily water from temporary storage back into the ocean which may result in dissolved and entrained hydrocarbons being released back into the marine environment. This is not expected to lead to additional environmental impacts compared to the pre-application state of this strategy as the decanted water will be released at the spill site within already affected boomed areas and not elsewhere. Thus, no additional adverse environmental impacts are expected for water quality and marine biota and the residual impact consequence is assessed as nil (Magnitude 0, Sensitivity – L).

Shoreline Cleanup – Disturbance to Ground

Conducting shoreline cleanup activities, including moving personnel and equipment, has the potential to cause damage to terrestrial and intertidal habitats, with subsequent impacts to dune/beach structure, flora such as mangroves and fauna such as turtles and birds (including nests). The impacts associated with undertaking shoreline clean-up may be more than if the product was left in place and remediated through natural processes (Natural Recovery). Leaving the product in place is a very common response option if continual human and vessel/vehicle traffic has the potential to generate greater impacts than the product itself. The optimal suite of response strategies will be determined through the SIMA process described in the OPEP.

Shoreline cleanup activities will be managed to minimise impacts on turtles (including hatchlings) and birds through minimising disturbance to nesting, and feeding sites. Responder transfer to shore would be on small boats or helicopters. Responders would be accommodated on nearby medium sized vessels or facilities such as Prelude (if available). Given the controls in place (Refer to the OPEP) and the short-term and localised incidental environmentel effects from shoreline clean-up activities, there would only be minor residual impact consequences presented by personnel and equipment undertaking shoreline clean-up activities (Magnitude -2, Sensitivity – M).

9.14.3 Impact Assessment Summary

Table 9-74 lists the highest residual impact consequence rankings of the relevant environmental receptor groups.

Table 9-74: Spill Response Strategies Evaluation of Residual Impacts

Environmental Receptor	Magnitude	Sensitivity	Residual Impact Consequence Ranking
Physical Environment	-2	M	Minor
Biological Environment	-2	M	Minor

Socio-economic and Cultural Environment[1]	N/A	N/A	N/A

1- Potential impacts to socio-economic and cultural environment receptors are not predicted to exceed those presented in Section 9.14 and are therefore not repeated in this section.

9.14.4 ALARP Assessment and Environmental Performance Standards

The required controls, EPSs, implementation steps and required capability associated with each of the spill response strategies is detailed in the OPEP and is not further discussed in the EP noting the options are selected in accordance with the SIMA process to ensure environmental net benefits and trade-offs are appropriately assessed and documented.

9.14.5 Acceptability of Impacts

New and/or unique environmental impacts associated with implementation of the possible spill response strategies are considered to be acceptable where they present a net environmental benefit compared to the 'do nothing' option as determined and documented through the SIMA process as described in the OPEP.

Assessment of these impacts from the spill response strategies discussed above determined the residual ranking of minor or lower (Table 9-74). The acceptability of these impacts has been considered in the context of:

Principles of ESD

The response option impacts described above are consistent with the principles of ESD based on the following points:

- The health, diversity and productivity of the marine environment will be optimised for future generations through minimising the impact of any large scale spills through implementation of the accepted OPEP and associated response stratagies;
- The precautionary principle has been applied, and studies undertaken where knowledge gaps were identified. This knowledge has been applied during the evaluation of environmental impacts
- With the prevention and mitigation controls in place, the conservation of biological diversity and ecological integrity shall be optimised following a large scale spill.

Relevant Requirements

Management of the impacts associated with spill response strategy implementation are consistent with relevant legislative requirements, including:

- The NOPSEMA accepted OPEP (HSE_PRE_013075).

Matters of National Environmental Significance

Threatened and Migratory Species

Alignment with the relevant management plans, recovery plans and conservation advice for threatened and migratory fauna will be addressed on a case-by-case basis through the SIMA process when selecting appropriate spill response strategies (Reference is made to Table 7-4 for the list of potentially applicable plans and advisory documents). These plans and advisory documents will assist with determining protection priorities once the nature, scale and trajectory of the spill is understood post event.

Commonwealth Marine Environment

The new and/or unique environmental impacts presented by dispersant application, decanting and/or shoreline cleanup on the Commonwealth marine environment when assessed in isolation from the spill event itself will not credibly exceed any of the significant impact criteria provided in Table 8-1.

External Context

There have been no objections or claims raised by Relevant Persons to date around the dispersant application, decanting or shoreline cleanup aspect. Shell's ongoing consultation program will consider statements and claims made by stakeholders when undertaking further assessment of the risks.

Internal Context

Shell has also considered the internal context, including Shell's environmental policy and ESHIA requirements. The environmental performance outcomes, and the controls which will be implemented, are consistent with the outcomes from stakeholder consultation for the Prelude FLNG facility and Shell's internal requirements.

Acceptability Summary

As outlined above, the acceptability of the associated impacts have been considered in the context of:

- The established acceptability criteria
- ESD
- Relevant requirements
- MNES
- External context (i.e. stakeholder claims)
- Internal context (i.e. Shell requirements).

The residual impacts have been assessed as minor which Shell considers to be acceptable if they meet legislative and Shell requirements. The discussion above demonstrates that these requirements have been met in relation to the new and/or unique impacts associated with implementation of the identified spill response strategies. Based on the points discussed above, Shell considers the residual impacts to be ALARP and acceptable.

9.14.6 Environment Performance Outcomes

Environment Performance Outcomes	Measurement Criteria
Spill response strategies shall be selected and implemented to minimise the overall environmental impacts from a spill and the associated implementation of the response strategies themselves.	OPEP implementation records and SIMA records

10.0 Environmental Plan Implementation Strategy

The OPGGS (E) Regulations require an Implementation Strategy to be incorporated into the EP that includes:

- Measures, systems and practices to ensure that environmental risks continue to be identified and reduced to a level that is ALARP, mitigating measures are effective, and environmental performance outcomes and standards are met
- Chain of Command
- Measures to ensure workers are aware of their responsibilities
- Monitoring and management
- Records and reporting
- Oil Pollution Emergency Plan (OPEP) provided as a separate document together with this EP submission
- Consultation.

10.1 Management Systems

The Shell HSSE & SP-MS provides a structured and documented framework for the effective management of HSSE & SP risks and demonstrates how the requirements of the Shell Group HSSE & SP Control Framework are implemented throughout Shell. The Shell HSSE & SP-MS Manual consists of the following sections:

- Leadership & Commitment
- Policy & Objectives
- Organisation, Responsibility & Resources, Standard & Documents
- Risk Management
- Planning & Procedures
- Implementation, Monitoring & Reporting
- Assurance
- Management Review.

The HSSE & SP-MS is subject to a continuous improvement 'plan, do, check, review' loop, with eight components as outlined in Table 10-1. There are numerous, specific ongoing (typically annual) assurance activities against each of the eight components in this HSSE & SP-MS Manual as detailed below. The audit and review function of the HSSE-MS seeks to ensure that the system is being implemented, is effective and to identify areas for improvement. Examples of elements that demonstrate continuous improvement are highlighted under each section.

Table 10-1: HSSE & SP-MS Elements Implementation and Improvement

Management System Element	Implementation and Improvement
Leadership and Commitment *Creating and sustaining a culture that drives Shell's commitment of no harm to people or the environment*	Seek ongoing feedback on how others perceive HSSE & SP leadership (performance reviews, HSE Culture Survey (Shell People Survey), 360 feedback)
Policy and Objectives *Supporting the implementation of Shell HSSE & SP Commitment and policy*	Set annual HSSE & SP targets to drive continuous performance Annually Review and approve HSSE & SP objectives
Organization, Responsibilities and Resources *Establishing and maintaining an organization that enables the compliance with the HSSE & SP Control Framework*	When there are changes in the Business or organization, identify the positions that require Competence assurance. HSSE & SP Critical Position Register, Shell People Competency Profiles
Risk Management *Identifying the HSSE & SP hazards and establishing the controls to reduce the risks to As Low as Reasonably Practicable (ALARP)*	Ongoing review of Hazards and Risks. Regular review of Risk Registers
Planning and Procedures *To integrate the requirements of the HSSE & SP Control Framework into business plan and procedures: Emergency & Crisis Response, Spill Preparedness and Response, MOC, PTW*	Establish and maintain a programme of testing of Emergency Response plans and procedures at least once a year or more frequently based on the level of risk. Shell Australia ERP, Records of ER drills, exercises and AARs.
Implementation, Monitoring and Reporting *Implement the HSSE & SP requirements embedded in plans and procedures and take corrective action when necessary*	Report all Incidents, including Near Misses, to the Supervisor of the work activity. Learn from Significant Incidents and High Potential Incidents through communication and implementation of required actions.
Assurance *Providing assurance that the HSSE &SP Control Framework requirements are implemented and effective*	Establish, maintain and execute HSSE & SP Self-Assessments in support of the Business HSSE & SP Assurance Plan, self-assessment, CF Gap Analysis, HSSE & SP Management Review. • Management Review (documents demonstrating how Shell Australia reviews the effectiveness, adequacy and fitness for purpose of the HSSE & SP Management System and take action to improve) • Review the HSSE & SP Management System and its individual elements at least once a year and document the results.
Management Review *Reviewing the effectiveness, adequacy and fitness for purpose of the HSSE & SP MS and taking actions for improvement*	Assess the Effectiveness and Adequacy of the management system in delivering the policy and Objectives and in driving continual improvement.

Shell's HSSE & SP-MS covers all operations within its business, including that of the Prelude FLNG Facility and all assets/operations (e.g. to Prelude and future operations).

Management of HSSE on the Prelude FLNG facility is through the implementation of the Shell HSSE MS, supplemented by facility/asset specific HSSE systems/procedures (e.g. Prelude Permit to Work system and associated procedures such as Confined Space Entry, Isolations, etc.).

Shell implements specific pre- and post-contract award processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks and deliver effective management of HSSE & SP risks for contracted activities.

Contractor HSSE & SP Management is governed by the Shell HSSE & SP Control

Framework. As a minimum, all relevant field active contractors' HSSE & SP-MS will be assessed to ensure they meet materially equivalent outcomes to Shell's HSSE & SP-MS.

For the activities that occur offshore but not onboard of the Prelude FLNG facility (e.g. vessel activities within the safety zone), Vessel Contractor predominantly use their own vessel/facility HSSE-MSs to manage work scope onboard their vessel.

10.1.1 Environment Critical Element Management

Environmentally Critical Element (ECE) is an item of equipment or structure whose failure could lead to:

1. the release of a major environmental hazard or whose purpose is to prevent or limit the consequences of a major environmental hazard (RAM Red or Yellow 5A/5B Environmental risks); or
2. environmental regulatory non-compliance as part of implementing the controls to manage environmental hazards to As Low As Reasonably Practicable (ALARP) and Acceptable levels

Environmentally Critical Elements are mostly equipment and are frequently referred to as Hardware Barriers.

Identification of ECEs, and assurance of their implementation effectiveness is an important element of ensuring that barriers will function as required. Figure 10-1 illustrates the overall process of identification of ECEs and integration with SCEs, the Business Management System (BMS) and the competency system. Figure 2 illustrates the relationship between ECEs and SCEs.

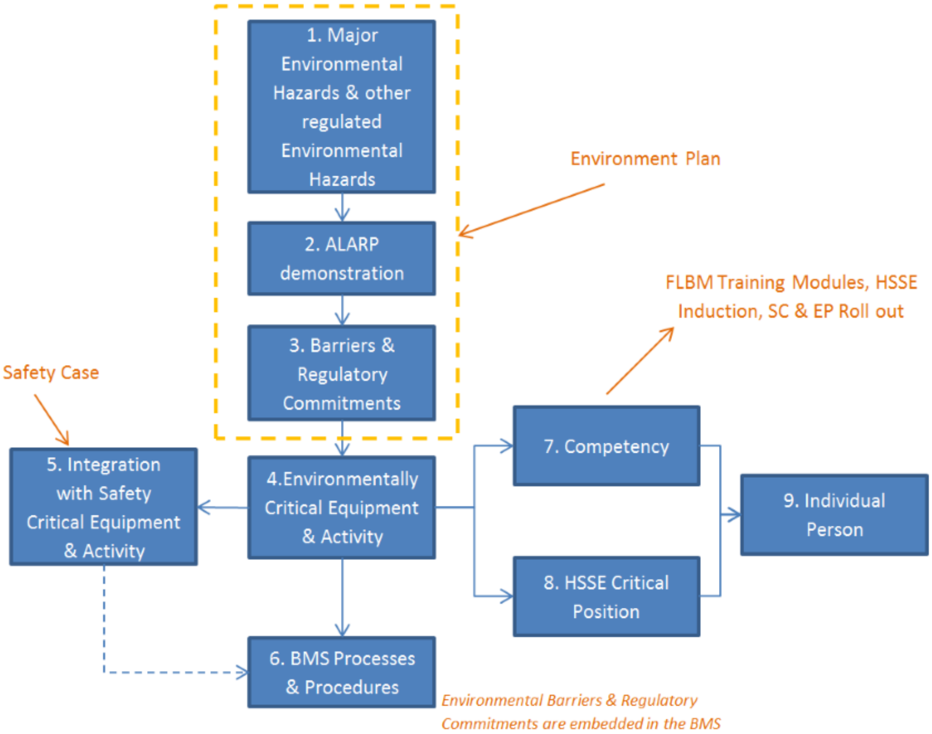

Figure 10-1: ECE Identification Process

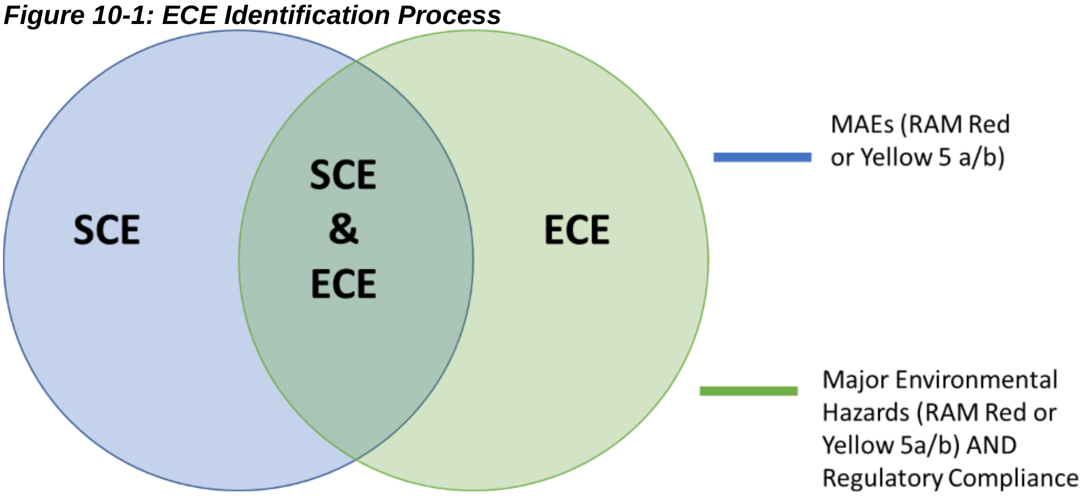

Figure 10-2: Illustration of the relationship between SCEs and ECEs

For Prelude FLNG, Major Environmental Hazards (RAM Red or Yellow 5a/b) are also associated with some Major Accident Events (MAE) in the Safety Case. Some Bowties within the Safety Case are also appropriate for managing the Major Environmental Hazards. Those Bowties were developed to illustrate the threats that can lead to the realisation of an MAE (incl. those associated with Major Environmental Hazards) and the barriers that can prevent this occurring or mitigate the consequences. Some ECEs are also SCEs.

Deviation

Deviations are able to occur through following the ECE management guidance (OPS_PRE_15791). This is an approved non-compliance of the mandatory requirements of a procedure, standard or specification. This is applied to assurance and environmentally critical corrective and preventative maintenance that will not be or has not been carried out by the due date.

Overides are able to occur following the ECE management guiance. An override is an interruption to the normal operation of an environmentally critical element that prevents it from performing the desired action.

10.1.2 Contractor Management

Contractors and their sub-contractors carry out a number of activities on behalf of Shell. Effective management of environment, integrity, health and safety risks in contracts involves setting clear expectations and managing these risks throughout the contract lifecycle.

Shell implements specific processes and activities aimed at ensuring that contracts consistently and effectively cover the management of HSSE & SP risks for the contracted activities. These processes are detailed in the Prelude HSSE & SP Contractor Management Strategy Manual. The contractor management processes implemented for Prelude FLNG are consistent with the requirements of the Shell HSSE & SP Control Framework Contractor HSSE Management Manual.

Key aspects of the Contractor HSSE Management are:

<u>Pre-contract Award Activities</u>

- Appointing a competent contract owner and contract holder for each contract.
- Determine the Contract HSSE & SP risk, by assessing the risk associated with the contracted activities.
- Determine the contract mode.
- For a high contract HSSE Risk, the contractor is to develop and provide a Contract HSSE Plan.
- Assess whether the Contractor has the capability and resources to manage the risks associated with the contracted activities.
- Before contract award, confirming that the Contractor meets requirements. Focus on closing gaps in draft contract HSSE & SP Plan submitted by Contractor.
- Define the level of Company monitoring based on the capability of the Contractor, the contract HSSE & SP risk and the contract mode.

<u>Post-contract Award Activities</u>

- Require the Contractor to demonstrate that Contractor personnel responsible for managing the HSSE Risks of the contracted activity have knowledge of the HSSE requirements of the contract and any associated Contract HSSE Plan related to their role.
- Require the Contractor to demonstrate that all Contractor personnel will be given an induction on the HSSE risks of the contracted activities including the controls to manage those Risks specified in the contract and any associated Contract HSSE Plan.

- Verify that the HSSE requirements of the contract and any associated Contract HSSE Plan are being implemented and are effective at managing the HSSE Risk of the contract. Where necessary implement actions for improvement.
- Regularly assess the HSSE performance of the Contractor, including its management of Subcontractors.

10.1.3 Contractor Competency Requirements and Assurance

The contractor is responsible for ensuring that all their personnel have the appropriate level of competence required to safely and effectively carry out the work. The contractor is also responsible for the development and implementation of a competence assurance plan. The contract holder is responsible for ensuring that the contractor's competence assurance system is reviewed, robust and meets the Shell requirements.

In addition to trade competencies and qualification requirements, the minimum competence requirements for key contractors working on Prelude are based on the required contractor work scope and are developed in consultation between Shell and the contractor. The minimum requirements for a contractor going offshore on the Prelude FLNG facility include the following:

- Facility Induction (such as Life Saving Rules, Emergency Response and Muster procedures, Incident Reporting, Waste Management, Oil Spill Awareness)
- Role-specific training such as Permit to Work, operating procedures of specific process units

10.1.4 Asset Integrity – Process Safety Management System (AI-PSM)

Shell AI-PSM focus areas are as follows:

<u>Design Integrity:</u>

- The aim is we design and build our assets so that risks are As Low As Reasonably Practicable (ALARP).

<u>Technical Integrity:</u>

- Barriers are put in place to manage Major Accident Events (MAEs). Technical Integrity ensures that we maintain the provided hardware barriers (from Design Integrity) to keep them effective. Section 11.1.6 describes the maintenance processes of the hardware barriers.

<u>Operating Integrity</u>

- Together with design and technical integrity, one key aspect of assuring our assets are safe is working within the operational barriers. Operational Integrity processes ensure that the facility is being operated within its design.

<u>Leadership Integrity</u>

- Leadership is the key enabler to ensure that we have assets that are safe to operate. Each leader plays an important role in safeguarding against process safety and environmental incidents and must demonstrate visible and felt leadership in the field.

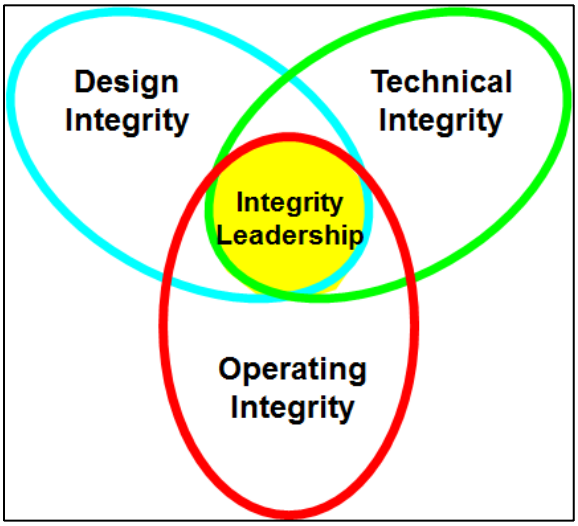

Figure 10-3: Shell AI-PSM Focus Areas

10.1.5 Asset Management System

Shell is implementing the global Shell Asset Management System (AMS) framework as a single, control framework for managing Producing Assets in Shell.

The AMS framework describes a set of processes needed to organise asset management capabilities, ensuring that activities are performed consistently in a joined-up manner and systematically improved to deliver excellent sustainable business outcomes.

It includes mandatory elements (through Standards and Manuals) and non-mandatory elements (through Recommended Practices), and should be used in conjunction with other Shell Control Framework requirements; for example the HSSE & SP Control Framework.

The Asset Manager is accountable for ensuring adherence to the AMS. The AMS standard provides all the tools and processes which help an asset get to at least the minimum requirements comprising four major sections:

1. Leadership, Commitment & Accountability
2. Requirements Processes & Guides
3. Organisational Capability
4. Learning Loops

10.1.6 Design and Operational Envelope

Prelude FLNG facility has been designed and built to ensure that the risks associated with process safety and environmental events have been managed to ALARP. This is part of the “Design Integrity” focus areas of the AI-PSM.

Design limits define the boundary of the design envelope for each piece of equipment and if violated could potentially lead to a loss of containment. These limits (such as pressure, temperature and level) have been set using industry and company standards and assured via various process safety reviews (such as HAZOP and Desktop Safety reviews).

Another key aspect of assuring the facility safe is working within the operational envelope. This is part of the “Operating Integrity” focus area of the AI-PSM. Operating envelope identifies the integrity and capacity constraints of a system, which is within the boundary of the design envelope. Limits to operating envelope (such as process trips and set points) are set in conjunction with process engineering Technical Authority and Process Automation and Control (PACO) and documented in the alarms variable table, taking account of equipment constraints and operator response time.

10.1.7 Maintenance & Integrity Execution

The management of maintenance and integrity in Prelude is in accordance with the Shell Group Maintenance & Integrity Execution processes. Implementation and embedding the processes ensures that Prelude is in a position to operate the FLNG facility in a safe and environmentally-responsible manner and realize the benefits of a proven maintenance execution process. Excellence in maintenance execution means ‘the right job, by the right person at the right time’; i.e. jobs that are approved, scoped, performed with the right competency and attitude, scheduled to be performed at a time that reflects the needs and risk of the business.

The proactive and visible management of critical equipment is a fundamental aspect of Technical Integrity Management. The execution of Integrity Assurance (IA) activities (the identification, prioritisation and subsequent execution of Integrity related corrective and preventative work) are executed through a common maintenance work management process. It is key that assurance/ IA tasks within the planned maintenance routines are identifiable and can be linked to the risk barriers; making it transparent that all risk barriers are in place and effective. The key IA activities within the maintenance process are summarized below and in Figure 10-4.

- Technical Integrity Data capture
    - Critical equipment including related equipment necessary for environmental protection are identified and then logged into the Shell MMS. Operate phase Performance Standards for this equipment are documented.
    - Integrity Assurance tasks against the relevant are logged into SAP.
- Training and coaching for managing & executing IA tasks
- Implementation of the process
    - Making sure all Preventive Maintenance work is executed to the correct standard and within the prescribed timeline.
    - Raising the need to attend to a breakdown and fixing it
    - Recording of history of work executed in the asset
    - Making sure the right work is being performed at the right time, with the right people, right tools, right access, etc. and that it is done safely!
    - Embed the use of Total Reliability measures
    - Activation and use of Facility Status Report (FSR) for Deviation Management and Visualisation. Further details on FSR are in Section 11.1.6.1 Key MIE Tools.

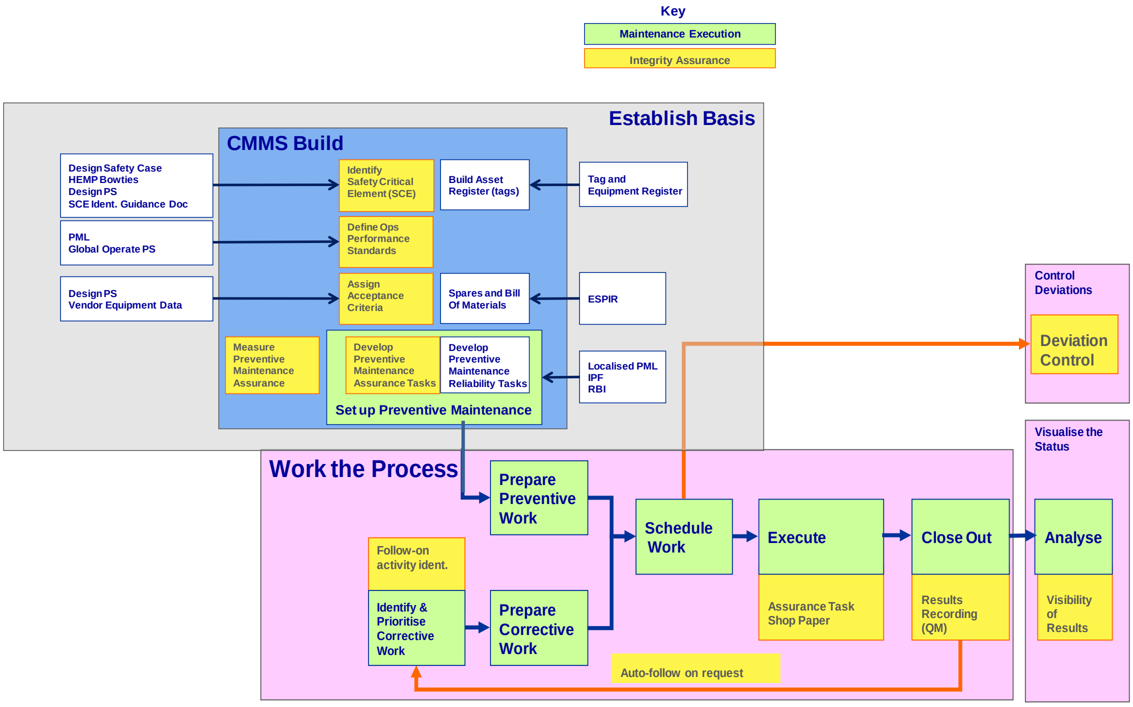

Figure 10-4: Maintenance & Integrity Execution Processes

11.1.6.1 Key MIE Tools

Table 10-2 lists the key tools currently used on Prelude to manage SCE hardware barriers. These tools may change over time as more effective options become available. Tools specific to SCE groups are discussed in the respective Integrity Management Plans.

Table 10-2: Technical Integrity management Tools

Tool	Name	Function
CMMS	Computerised Maintenance Management System	Contains Prelude Asset Register with SCE identified Maintenance work planning, scheduling and execution management Documentation of completion of maintenance work Business Warehouse function for maintenance KPI reporting and analysis Quality Module for analysis of maintenance work Integrated with other business systems for purchasing, materials management, finance and logistics
CIMS	Corrosion and Inspection Management System	Master source of inspection schedules and records for pressure equipment and structures Interfaces with CMMS for scheduling and status of inspection activities (as PM work orders)
IMSA	Integrity Management System Application	Integrity management software for pipelines and underwater assets (apart from wells).
FSR	Facility Status Report	Status of Preventive Maintenance and Corrective Maintenance work orders and deviations

eWIMS	Wells Integrity Management System	Management of wells specific integrity tasks. Interfaces with CMMS for scheduling and status of tasks (as CM or PM work orders)

10.1.8 Permit to Work (PTW)

The Permit to Work (PTW) process is used to control and approve work on the Prelude FLNG facility and within the Prelude Safety Zones. It ensures that adequate controls and measures are in place to safeguard people, asset and environment from work activity hazards. Details of the PTW process is described in the Permit to Work Manual (HSE_PRE_004404) and an electronic PTW system is used. There is a high level redundancy built into the electronic PTW tool.

A permit is required for activities that have the potential to adversely affect personnel's safety/health, cause damage to asset, the environment and reputation. Most activities on Prelude FLNG require a permit; examples include hot work, breaking containment and confined space entry. However, there are standard operational and marine operations activities that do not require permits and are managed through approved procedures; execution of these activities is allowed only after safety and environmental precautions have been put in place.

All permitted activities on Prelude are categorised based on their risk level: into low-low, low, medium or high risk. The level of risk assessment, review and approval are proportionate to the risk of the activity.

10.1.9 Management of Change (MOC)

The Management of Change process for Prelude FLNG is described in the Shell Management of Change (MoC) Manual. The MoC process is designed to "provide assurance that, when changes are introduced, new risks are not knowingly incurred, or the prevailing risk profile is not adversely changed without appropriate mitigation".

The scope covered by this manual includes:

- Process Changes (Hardware, Process Control, Process Conditions)
- Procedural Changes that affect HSSE Critical Content
- Organisational Changes (Shell and Contractor) impacting HSSE Critical Roles.

The application of this scope includes:

- Permanent Change
- Temporary Change
- Emergency Change.

The MoC Manual is supported by specific procedures, templates and checklists. The progress of change requests is monitored through an electronic MoC system.

The MoC process is built around 7 simple steps forming an overarching governance framework (Figure 42).

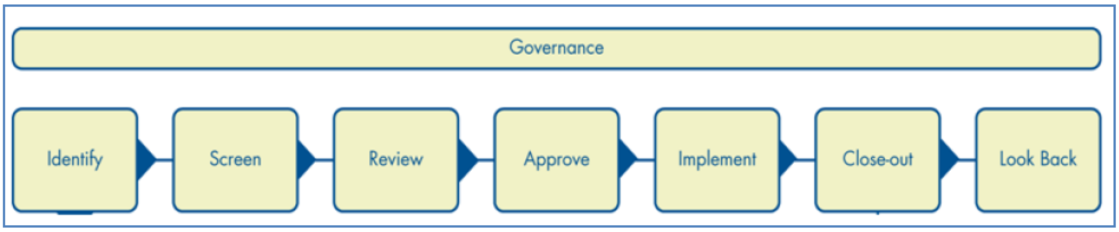

Figure 10-5: Management of Change Process Steps

The screening process for all new changes (hardware or software) require assessment of HSSE&SP aspects as per Management of Change (TEC_GEN_001465) this may result in a change being flagged as possibly needing a change to the EP which require compliance with Regulation 17 of the Environment Regulations. If a change is considered significant as per Regulation 17 (5) or (6) and as determined by the MOC process, then a revised or new EP will be submitted to NOPSEMA for acceptance. The following examples or scenarios would generally be considered significant changes:

- Tie-in of new wells, reservoirs or facilities
- Major unplanned subsea repairs
- Drilling new production wells
- Major process changes which result in significant increases in environmental risks or impacts.

The following will also trigger the review of the management of a particular environmental impact or risk to ensure that ongoing management of impacts and risks are at ALARP and Acceptable levels:

- Changes in regulatory requirements/standards
- Information which may suggest an increase in environmental risks or impacts to those outlined in the EP
- Prominent new scientific studies which may 'negatively' change the understanding of environmental risks and impacts
- Objections or claims raised which require changes in EP content following the process outlined in Section 5.0.

10.1.10 Chemical Selection Process

Shell has adopted a chemical selection and approval process in accordance with Shell's chemical selection and approval guidelines as indicated in Shell Chemical Management Process (HSE_GEN_007879) and Shell Global Product Stewardship guidelines to assess chemicals than may pose environmental impact via planned discharges.

All chemical applications are required to be screened in accordance with Shell Global Product Stewardship guidelines (Figure 10-6)

Where chemicals may be discharged to the marine environment preference shall be given to chemicals that are deemed environmentally acceptable (PLONOR, Gold, Silver, D and E) with no substitution warning under the Offshore Chemical Notification Scheme (OCNS) adopted in the United Kingdom and the Netherlands. Chemicals that fall within this banding require no further assessment and are deemed ALARP and accepted.

Chemicals that do not have an OCNS ranking or fall outside of the preferential banding (PLONOR, Gold, Silver, D and E with no substitution warning) are required to be assessed further incorporating seeking a suitable alternative chemical of lower environmental impact. If no alternative is technically suitable, the chemical is required to be assessed via Shell Global Product Stewardship guidelines and ALARP demonstration with risk reduction control measures (Figure 10-7). Approval will be provided by the Shell Production Chemist / Product Steward Focal Point. Chemicals that are not deemed ALARP will be not approved and an alternative product shall be requested.

To ensure that chemicals which may pose impact to the marine environment are managed appropriately on an ongoing basis, annual compliance checks will be made by Shell and chemical vendors of Shell's Chemical Programme Treatment Guide (TEC_PRE_006805) and Chemical Risk Assessment Register operational chemical registers. To accompany routine compliance checks, the impact of chemicals in key discharge streams will be assessed on an ongoing basis as indicated in Adaptive Management Framework outlined in Section 10.4.1.

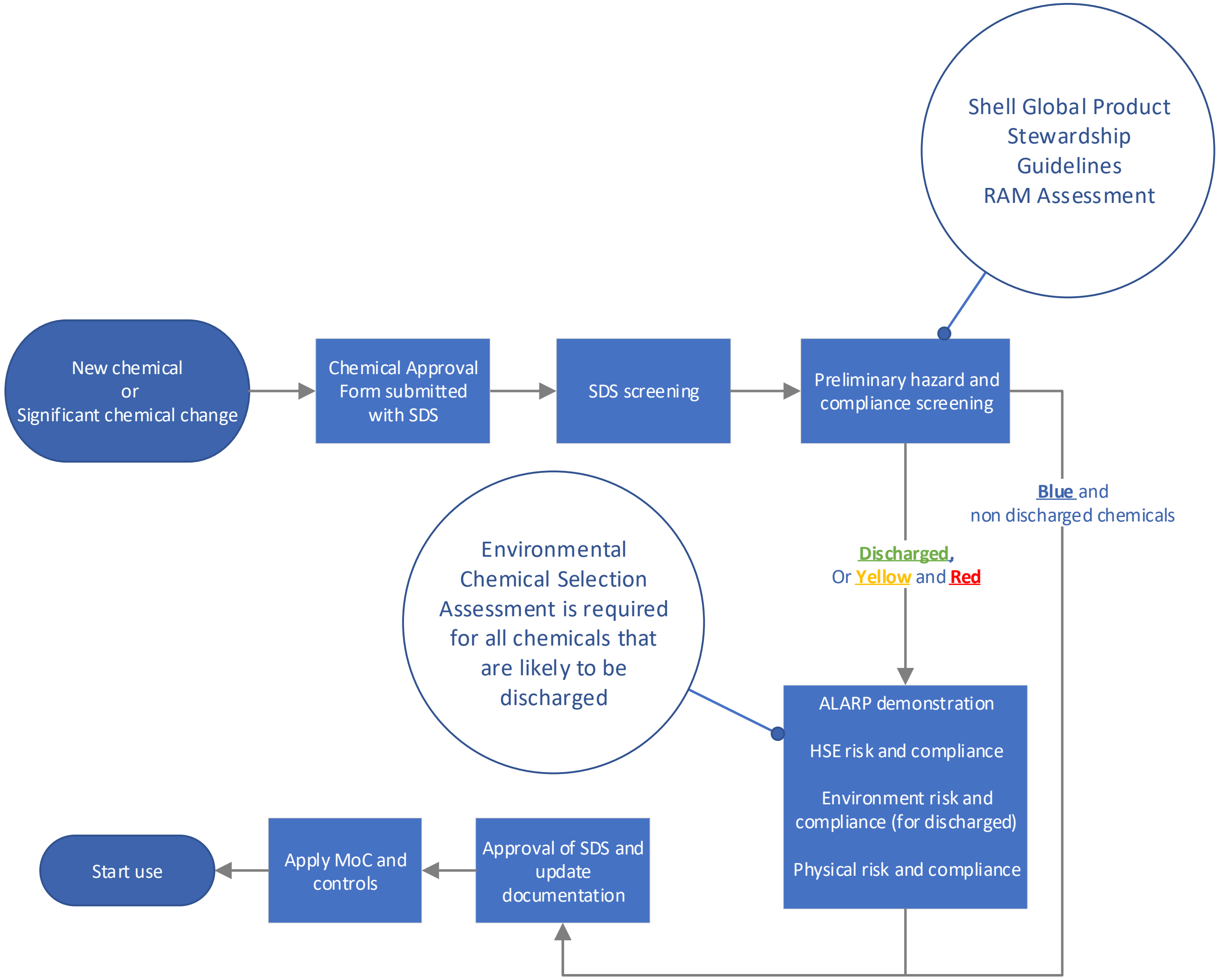

Figure 10-6: Chemical Approval Process

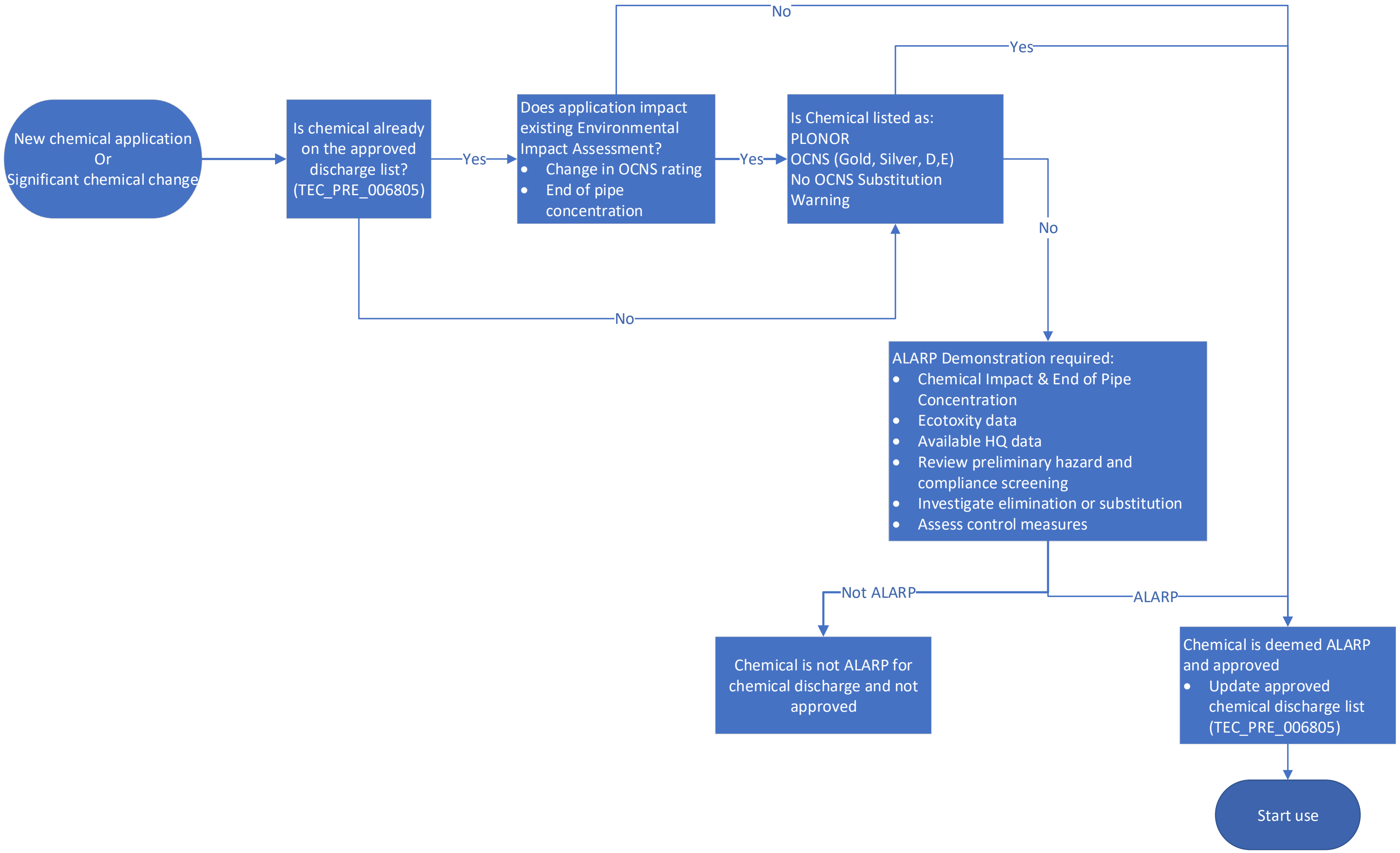

Figure 10-7: Environmental Chemical Impact Assessment

10.2 Organisation, Roles and Responsibilities

The overall structure of Prelude FLNG is summarised in Figure 10-8. The core organisation of Prelude consists of the Prelude FLNG Asset Manager, reporting to the Vice President Prelude. The Asset Manager is accountable for the safe and environmentally responsible operation of Prelude.

The facility Offshore Installation Manager (OIM) who reports into the Production Manager has overall field authority for work on and within the safety zone. The offshore organisation is supported by a core onshore organisation which includes Shell's technical and other support departments providing both frontline and long term engineering services including but not limited to:

- Engineering and maintenance standards/guidelines and supporting governance processes;
- Engineering and maintenance strategies, systems and applications to support and optimise operations; and
- Coordination of production engineering and maintenance execution processes and resources.

As required by Regulation 14(4) this section of the Implementation Strategy establishes a clear chain of command that sets out the roles and responsibilities of personnel in relation to the implementation, management and review of the EP, including during emergencies or potential emergencies, ranging from senior management to operational personnel that support Prelude and support vessels.

The roles, responsibilities and accountabilities for processes undertaken are detailed in the Business Management System and individual's job descriptions. General responsibilities associated with this EP for key personnel are summarised in Table 10-3.

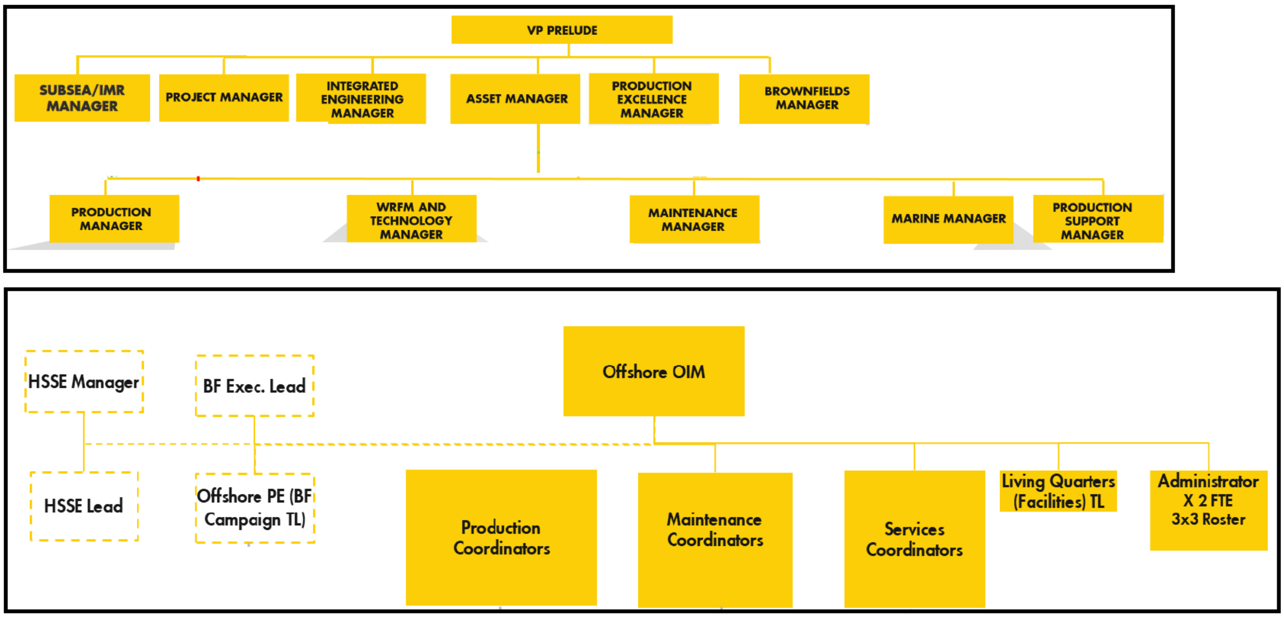

Figure 10-8: Offshore Organisation Structure

Table 10-3: Key Responsibilities

Position	Responsibilities
Prelude Asset Manager (EP Owner)	**Systems, Practices and Procedures** • Accountable for the overall operation of the Facility. • Accountable for ensuring all necessary regulatory approvals are in place to operate. • Accountable for the implementation and compliance of the EP. • Accountable for safe, efficient and environmentally sound operation of the Facility in accordance with the EP, legislative requirements and Shell's policies and standards. • Custodian of communication with all regulatory agencies required to operate the Facility. • Accountable and responsible for agreeing and meeting KPIs and environment initiatives from annual Plans and reviewing environmental performance to drive continuous improvement. • Accountable for the implementation of stakeholder consultation as per the description in this EP and in compliance with regulations.
Engineering Manager	**Systems, Practices and Procedures** • Accountable for overall engineering compliance with all legislative requirements. • Accountable for ensuring that the management of change and engineering support workflow systems and processes are adhered to. • Accountable for compliance with all engineering elements of business processes within the defined area/asset including the management of change workflow. • Accountable for achievement of all engineering KPIs, risk assessment and mitigation.
Well, Reservoir and Facility Management (WRFM) & Technology Manager	**Systems, Practices and Procedures** • Accountable for overall day-to-day process engineering, production chemistry and laboratory compliance with all legislative requirements. • Accountable for process optimisation. • Accountable for ensuring that the process surveillance, production chemistry and laboratory workflow systems and processes are adhered to. • Accountable for achievement of all Technology KPIs, risk assessment and mitigation.
Production Manager	**Systems, Practices and Procedures** • Responsible for the overall operation of the Facility. • Responsible for the implementation and compliance of the EP. • Responsible for safe, efficient and environmentally sound operation of the Facility in accordance with the EP, legislative requirements and Shell's policies and standards.

<table>
<tr><th>Position</th><th>Responsibilities</th></tr>
<tr><td></td><td>
Responsible for agreeing and meeting KPIs and environment initiatives from annual Plans and reviewing environmental performance to drive continuous improvement.
Resourcing, Training and Competencies
Puts in place adequate resources (technical, environmental, engineering, information, financial) to implement and meet all requirements of the EP.
Establishes and maintains a workforce with the necessary knowledge, skills and competencies to operate and maintain the Facility in accordance with the requirements of the EP.
Monitoring, Auditing, Non-conformance and Emergency Response
Accountable for monitoring performance against the EP.
Accountable for implementing agreed assurance activities and monitoring close out of actions.
Accountable for incident notification, reporting and investigation in line with Shell and EP requirements.
</td></tr>
<tr><td>Offshore Installation Manager (OIM)</td><td>
Systems, Practices and Procedures
In charge of the Prelude FLNG facility and the field.
Accountable for the implementation of the EP at the facility.
Ensures offshore personnel comply with regulatory requirements and Shell’s policies and standards.
Accountable for ensuring all teams operate in a safe and reliable manner to meet production targets within the defined operating and technical integrity envelopes.
Accountable for the Permit to Work governance, process and permit requirements.
Implements environment initiatives from the Integrated Activity Plan including review of environmental performance to drive continuous improvement.
Ensures effective communication with workforce on environmental performance.
Accountable for effective and appropriate handovers between shifts.
Resourcing, Training and Competencies
Provides appropriate offshore resource allocation to meet the EP requirements including performance outcomes, standards and measurement criteria.
Accountable for the performance and development of production, services and maintenance teams and ensuring capability and competency across all shifts.
Monitoring, Auditing, Non-conformance and Emergency Response
Accountable for monitoring performance against the EP.
Implements environmental assurance activities and audits and implementing and monitoring close out of recommended actions.
</td></tr>
</table>

Position	Responsibilities
	• Ensures incidents are reported and investigated in line with Shell Australia standards and EP requirements, with appropriate actions initiated and closed out. • Responsible for acting as the Incident Controller during emergencies. • Responsible for ensuring exercises and drills are carried out such that the facility's ability to respond effectively to an emergency is assured.
Offshore Production and Services Coordinators	**Systems, Practices and Procedures** • Responsible for ensuring compliance to all environmental regulatory requirements as defined in this EP and Shell standards and procedures. • Accountable for the day-to-day operations of the facility including effective shift handover, completion and logging of operator routine environmental performance. • Responsible for leading and coordinating a multi-disciplined team performing specific duties to support the asset integrity of the facility, including helicopter operations, vessel movements and movement of goods and materials. • Implements environmental initiatives. **Resourcing, Training and Competencies** • Resource planning and allocation for the operations team • Management and coordination during emergencies **Monitoring, Auditing, Non-conformance and Emergency Response** • Responsible for assisting with assurance activities and incident reporting and investigation as required.
Offshore Maintenance Coordinator	**Systems, Practices and Procedures** • Responsible for ensuring compliance to all relevant environmental regulatory requirements as defined in this EP and Shell standards and procedures. • Responsible for the execution of the maintenance work plan to manage asset integrity of the facility and to support the EP. • Accountable and responsible for permitry and isolation for all frontline maintenance activities. **Resourcing, Training and Competencies** • Resource planning and allocation for the maintenance team. • Management and coordination during emergencies **Monitoring, Auditing, Non-conformance and Emergency Response** • Responsible for assisting with assurance activities and incident reporting and investigation as required.
Offshore HSSE Advisors	**Systems, Practices and Procedures** • Liaises with OIMs and Coordinators/Team leads on day-to-day management of environmental risks and issues.

Position	Responsibilities
	• Identifies opportunities for continuous improvement and communicates these to the OIMs and Shell Australia Environment Team. **Resourcing, Training and Competencies** • Coaches and assists in implementing environmental improvement initiatives. • Coaches relevant personnel understand the requirements in the EP applicable to their role. **Monitoring, Auditing, Non-conformance and Emergency Response** • Assists with the ongoing promotion of environmental performance at the facility including environmental reporting, monitoring and review. • Assisting with assurance activities and incident reporting and investigation as required.
Shell Australia Environment Manager	**Systems, Practices and Procedures** • Overall coordination of environmental management across Shell Australia to ensure the performance outcomes, standards and measurement criteria of the EP are met. • Ensuring the organisation understands and adheres to regulatory requirements and environmental management system. • Guiding and driving the direction of environmental management across the organisation, maintaining alignment with Shell Group's environment direction. • Providing support on environmental standards and EP compliance through the Shell Australia assurance programs. • Monitoring and communicating to the organisation any relevant changes to legislation, policies and regulator organisation that may impact the EP or the business. • Functional support on developing and maintaining appropriate environmental processes for Prelude. **Resourcing, Training and Competencies** • Supporting the Divisional environmental performance through implementation of effective environmental training programs. **Monitoring, Auditing, Non-conformance and Emergency Response** • Monitor and review progress against environmental improvement plans, targets and KPIs with divisional management to drive continuous improvement.
Prelude HSSE manager	**Systems, Practices and Procedures** • Monitor and review progress against EP, targets and KPIs with Prelude management to ensure compliance with the EP and drive continuous improvement. • Escalate to Prelude Leadership Team any potential environmental issues and non-compliances to ensure ownership by the line.

<table>
<tr><th>Position</th><th>Responsibilities</th></tr>
<tr><td>Prelude Environment Advisor</td><td>Systems, Practices and Procedures
Ensuring appropriate personnel have access to the EP and understand the outcomes, standards and measurement criteria and their environmental responsibilities for the activity.
Liaising with applicable regulatory authorities and stakeholders as required.
Develops risk reduction strategies and defines Performance Standards.
Facilitates ALARP & Acceptability reviews.
Update of the EP as required.
Facilitate and provide coaching for environmental improvement plans.
Resourcing, Training and Competencies
Developing and maintaining environmental training, and coaching materials for deployment to Prelude organisation.
Monitoring, Auditing, Non-conformance and Emergency Response
Responsible for environmental monitoring and reporting requirements from the EP including environmental performance and compliance reporting.
Monitoring progress against environmental improvement plans.
Participating in environmental audits/inspections to ensure regular checking of compliance to this EP. Communicating findings to management and assisting with close out of actions.
Assisting with review, investigation and reporting of environmental incidents.</td></tr>
<tr><td>External Relations Advisor</td><td>Responsible for preparing and implementing Prelude Stakeholder Engagement Plan.</td></tr>
<tr><td>Vessel Masters</td><td>Responsible for taking action immediately to rectify any environmental incident on the vessel.
Implementation of the EP on board the vessel.
Ensure effective operation of the vessel, taking into account relevant environmental aspects.
Communication of vessel environmental management activities on board.
Maintain administration of vessel’s environmental management system requirements
Ensure all crew members comply with the EP.
Manage any spills per SOPEP.
Responsible for ensuring cetacean sighting recording is undertaken.
Maintain good housekeeping and cleanliness around the vessel;
Compliance with DAFF and other marine regulations</td></tr>
</table>

Position	Responsibilities
Contract Holders	• Ensuring implementation of this EP for the contractor's scope of work. • Ensuring contractors have adequate environmental capability in order to execute their scope of work. • Reviewing and provide assurance over contractor environmental performance.
All personnel	• Complying with standards and procedures that apply to their area of work. • Immediate reporting of any environmental hazards or incident to the supervisor. • Understanding the environmental risks and controls applicable to work. • Following instructions from the OIM or supervisor with respect to environmental protection and measurement criteria outlined in this EP. • Undergo environmental training as required by role and activity. • Carry out assigned activities in accordance with approved procedures and the EP. • Stop any operation or activity that is deemed to present an unacceptable risk to the environment.

10.3 Competence and Inductions

10.3.1 Competency

All personnel required to work on Prelude installation activity are required to be competent to perform their required tasks. However, there is a subset of the workforce whose duties are sufficiently critical to the safe running of our operations that they require Competence Assurance. These are people in HSSE Critical Positions who are directly responsible for the safety of operations. These positions include the following:

- HSSE Critical Leader positions
  - Senior Management position at Leadership Team level with Operational, Technical or Engineering responsibilities with RAM red or yellow risks
  - Operational, Technical or Engineering position responsible for defining ALARP for RAM red or yellow Risks for a project, technical department or asset
    - Operational, Technical or Engineering position accountable for delivering ALARP for RAM red or yellow Risks for a major asset, group of small assets, major project or group of small projects.
- Technical Authority Level 1 and Level 2
  - Technical Authority Level 1 or 2 roles, which involve design, implementation and maintenance of barriers established for managing hazards with RAM red or yellow risks are deemed HSE Critical.
  - Required to be 'Skill' level at relevant technical and operational competencies.
- Frontline Barrier Management (FLBM)

- Positions directly responsible for implementing or maintaining barriers established for managing hazards with RAM red or yellow risks. These are mainly the production, maintenance and service technicians.

Personnel in HSSE Critical Leader positions are required to demonstrate the required level of competency in Lead, Prepare and Apply HSSE & SP Risk Management, subject to their Proficiency Profile. The HSSE critical leader positions are required to be skilled on the Lead, Prepare and Apply HSSE & SP risk management competency elements. Current list of HSSE Critical Leader position and their competence requirements is maintained by Shell Group.

Live registers for HSSE Critical Leaders positions are kept by both Shell and Prelude Project teams.

Shell has a defined set of Technical Authorities. Where a Technical Authority is not available within Shell, access is available to the Shell Global Technical Authority pool. A list of competent TAs is maintained globally through the Discipline Authorities Manual (DAM).

The register assigns a HSSE profile to each role and defines required proficiency levels for each profile. After assessment of individual competencies against position requirements, proficiency gaps will be addressed in training and coaching.

Additionally, all Shell positions in the organisation have detailed job descriptions including Competency Requirements. Company personnel working offshore require mandatory training as defined in the Training Strategy and Competence Management Plan. This matrix specifies the required HSSE & SP competence and training requirements for Shell staff who carry out specific activities during the Offshore Execution Phase. This plan also specifies training providers who are approved to provide such training. The training matrix is built based on requirements for Shell Group HSSE & SP Control Framework and Australian regulatory requirements. This plan also covers the minimum HSE training requirements for visitors.

Contractors have their own Competence requirements in place as described in Section 10.1.3. Training records of all personnel will be maintained and the training program will be reviewed on a regular basis.

10.3.2 EP Training

OPGGS(E) Regulation 14(5) requires that the implementation strategy must include measures to ensure that each employee and contractor working on, or in connection with, the activity is aware of their roles and responsibilities in relation to the EP.

All employees and contractors working on or in connection with Prelude with defined responsibilities to fulfil as part of the EP are required to attend EP Training that is formally tracked.

The Prelude EP Training shall cover the following items:

- Legislative requirements
- Ecological and socio-economic values of the project area
- Key environmental aspects, impacts and risks
- Shell's key EP Commitments
- Environmental management requirements, such as:
  - Liquid discharges management

- Drainage system management
- Emissions management
- Chemical and hydrocarbon management
- Waste management
- Marine fauna interaction
- Reporting of environmental incidents (such as spills)
- Emergency Response (including spill response).

On arrival at the facility or vessel, personnel (including short-term visitors) attend an onsite orientation designed to familiarise them with the general operations and location of key areas. The orientation explains the site-specific safety, environmental and emergency response aspects.

10.3.3 Oil Spill Training

Minimum training requirements for key oil spill response personnel include:

- IMO 3 (or equivalent) training[9] - IMT (W) Leader
- IMO 2 (or equivalent) training[10] - Operations, Logistics, Planning Section Chiefs, Environment Unit Lead.

10.4 Monitoring, Assurance and Incident Investigation

This section of the EP outlines the measures undertaken by Shell to regularly monitor the management of environmental risks and impacts of the Prelude activities against the performance outcomes, standards and measurement criteria, with a view to continuous improvement of environmental performance. The effectiveness of the Management System is also reviewed periodically as part of the monitoring and assurance process.

10.4.1 Environmental Performance Monitoring

Monitoring and review of environmental performance of the Prelude FLNG facility is done in a number of ways including monitoring of emissions and discharges, and through the use of various tools and systems. These monitoring systems meet the requirements of the following:

- Shell Australia Environmental Reporting Procedure (HSE_GEN_003179)
- Shell Australia Offshore Environmental Regulatory Approvals & Compliance Procedure (HSE_GEN_003180).

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[9] If IMO qualification are obtained, they may not be kept current in line with the current 3 year update requirements as internal exercising is considered enough to maintain the ongoing training levels for personnel in these roles.

[10] If IMO qualification are obtained, they may not be kept current in line with the current 3 year update requirements as internal exercising is considered enough to maintain the ongoing training levels for personnel in these roles.

In accordance with OPGGS(E) Regulation 14 (7), the implementation strategy must provide for sufficient monitoring of, and maintain quantitative records of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

Parameters that are monitored and recorded during operation of the FLNG facility are detailed in relevant parts of Section 5.0 and in the performance outcomes, standards and measurement criteria table in Section 6.0, and are summarised in Table 10-4.

Table 10-4: Emissions and Discharges Monitoring for Prelude FLNG Facility

* Where online analysers are the primary monitoring equipment/methodology and where not specified, the intent is always that if the online analyser is not available, manual sampling or estimation would be used as a contingency.

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
Drainage Discharge	Oil Content Flow	On-line	On-line analysers	PI Database	Section 9.9
Treated Produced Water Discharge	Flow Total Petroleum hydrocarbons	On-line	On-line analysers	PI Database	Section 9.9
	Chemical characterisation and WET sampling analysis per Table 10-6	Per Table 10-6	Sampling and third-party laboratory analyses	External laboratory reports	
Cooling Water Discharge	Flow Free chlorine Temperature	On-line	On-line analysers	PI Database	Section 9.9
Brine Discharge	Flow	On-line	On-line analysers	PI Database	Section 9.9
Boiler Blow-down Discharge	Flow pH	On-line	On-line analysers	PI Database	Section 9.9
Neutralisation Tank Discharge	Flow pH	On-line	On-line analysers	PI Database	Section 9.9
Emissions from boilers	Fuel consumption GHG emissions	On-line (Flow) On-line Gas Chromatographs Engineering Calculations	Hydrocarbon & Air Emissions Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and Section 9.11

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
	Particulate matter (PM) Sulphur dioxide (SO_2) Nitrous oxide NOx) Carbon monoxide (CO)	Once off within 18 months performance testing completion for specified plant equipment. Frequency of this stack sampling will be reviewed based on performance.	Stack sampling and third-party laboratory analyses	External laboratory reports NPI Reports	Section 9.10
Diesel fuel used on the FLNG and support vessels	Sulfur content	As required (every delivery)	Delivery certificates Laboratory sampling	Delivery certificates	Section 9.10 and Section 9.11
	Volume used	Monthly	Delivery certificates and storage tank volumes	PI Database Delivery certificates	
Flaring emissions	Total gas flared GHG emissions Sulphur dioxide (SO_2) Nitrous oxide NOx) Carbon monoxide (CO)	On-line (flow) Engineering Calculations	Hydrocarbon Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and Section 9.11
Acid gas vented	Total gas vented GHG emissions	On-line (flow) Engineering Calculations	Hydrocarbon Accounting Methodology	PI Database NPI and NGER reports	Section 9.10 and Section 9.11
Fugitive emissions	GHG emissions	Online (HP separator flow) Engineering Calculations	Hydrocarbon Accounting Methodology	NPI and NGERS reports	Section 9.10 and Section 9.11
Waste generation	Hazardous Waste Non-Hazardous Waste	Monthly	Waste records/manifests	Monthly waste reports	Section 9.12
Accidental releases of hydrocarbons or chemicals	Volume of accidental release	As required	If unmetered, volumes will be estimated based on technical data and evaluations	Incident reports in Fountain Incident Management	Section 9.13.

Source	Parameter to be Monitored	Monitoring Frequency	Monitoring Equipment/ Methodology*	Records	EP Reference
	Characteristic of release		(e.g. known well flow rates, production flowrates, pressure, duration of release and known inventory volumes)		
Ad Hoc liquid discharges from FLNG	Water quality Volume of discharge	As required.	Laboratory sampling as required.	MOC records	Section 9.9.

10.4.2 FLNG Liquid Discharges Adaptive Monitoring and Management Framework

Overview

This section contains details of an adaptive monitoring and management framework (framework) for Prelude FLNG water discharges. The framework's overall aim is to continually manage impacts from Prelude FLNG water discharges to ALARP and acceptable levels. Note that the primary focus of this framework is on PW discharges given this stream presents the greatest predicted impact of all the discharges (Section 9.9) when assessed in isolation. However, potential contaminants from other discharges are also included where relevant based on nature and scale of the associated impacts. Methodologies for the monitoring program will be consistent, allowing results to be compared and trends to be analysed over time.

The framework ensures the nature, extent, and potential effect of the PW, CW and other discharges are adequately assessed, and helps determine and assess the nature and scale of changes to water quality in relation to applied triggers and thresholds. The framework comprises several monitoring program components, as summarised in Table 10-5 below and conceptualised in (Figure 10-9). The framework is further detailed and proceduralised in the Prelude Liquid Discharges Monitoring and Management Procedure.

Table 10-5: FLNG Wastewater Adaptive Monitoring and Management Framework – Monitoring Programs

Monitoring Program	Frequency	Further Detail
Topsides monitoring	Ongoing (Refer Table 10-4) Additional monitoring as a result of trigger exceedences	Refer to Table 10-4 and Table 10-6
PW Chemical Characterisation	Annually Tests to coincide with WET testing Additional testing as a result of trigger exceedences or significant change	Refer to Table 10-4 and Table 10-6
PW WET testing	Commence within 18 months of startup, then 6 monthly for first 18 months, then triennial thereafter.	Refer to Table 10-7

	Additional WET testing as a result of trigger exceedences or significant change (Table 10-10)	
Field water quality sampling	5-yearly Additional field sampling as a result of trigger exceedences	Refer to Table 10-8
PW Model verification	5-yearly Additional model verification as a result of a trigger exceedences	Refer to Table 10-9

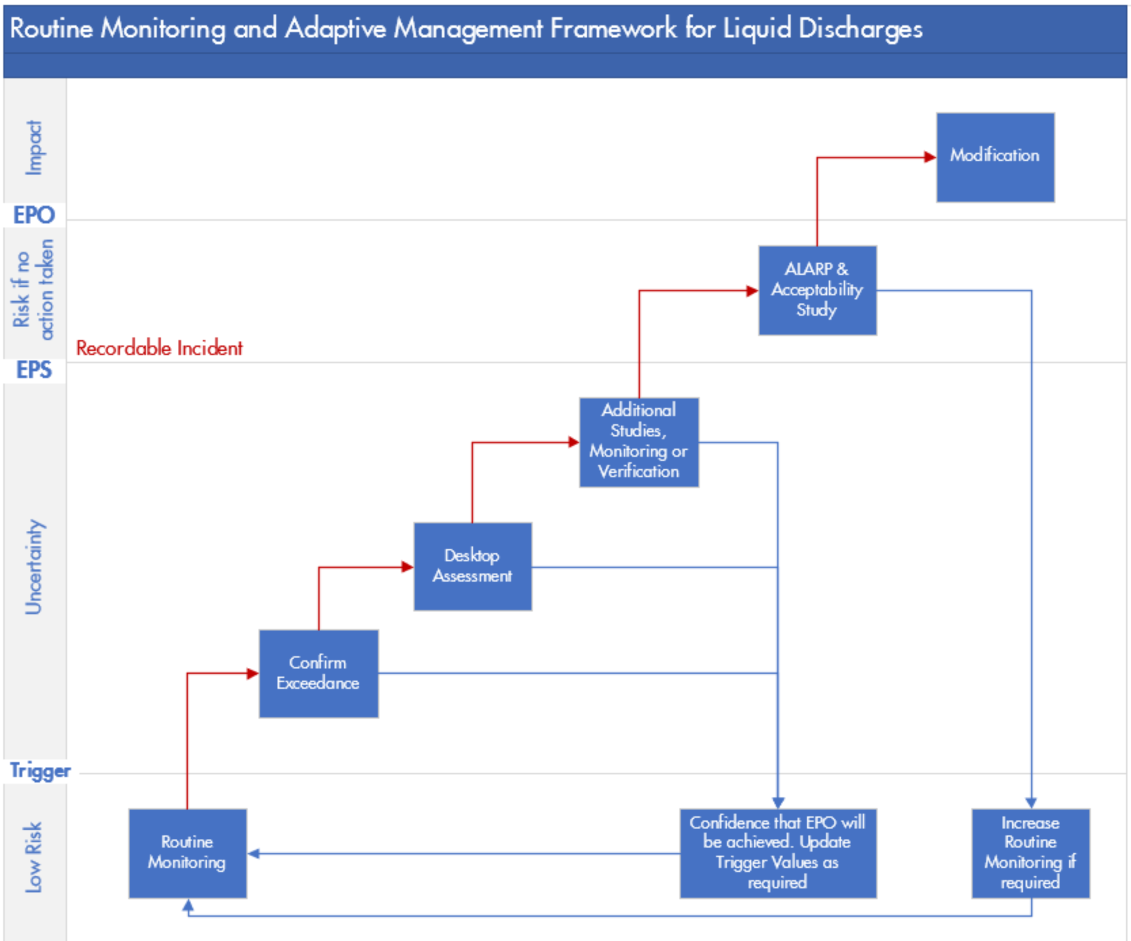

Figure 10-9: Conceptual diagram of adaptive monitoring and management framework

FLNG Topsides Monitoring

The overarching objective of the topsides monitoring program is:

- to use data collected topsides from PW and CW discharge, combined with modelling predictions, to assess whether the defined threshold/trigger values are likely to be exceeded beyond the predicted mixing zone(s) and for how long this has or will continue to occur (duration).

The main components of topsides monitoring to support the ongoing impact assessments, as well as other wastewater data are listed in Table 10-4, Table 10-6 and Table 10-7.

Table 10-6: FLNG Wastewater Discharges – Topsides Monitoring

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
Routine operational monitoring of discharges (Refer to Table 10-4 for specific components)	Enable management of key discharges within set triggers, EPS and EPOs.	Ongoing throughout operations at agreed intervals (see Section 9.9 and Table 10-4).	Refer to Table 10-4.	No action required if parameters/constituents are within predicted and assessed ranges. Where these levels are exceeded, the relevant actions in accordance with the Prelude Liquid Discharges Monitoring and Management Procedure (HSE_PRE_012355) are to be implemented and assessment undertaken against the relevant EPS to determine if the incursion constitutes a Recordable incident.
PW Chemical Characterisation	Determine PW chemical constituents and concentrations to compliment WET testing data to enable assessment if thresholds are triggered on the WET test Study. If this is exceeded, the following objectives apply to the PW chemical characterisation: • compare against assumptions made in impact assessments and identify the need for additional studies to understand impacts if discharge concentrations have been significantly underestimated; • compare composition against the applicable ANZECC DGVs, or other defined trigger values; and • monitor changes in chemical composition through time to identify long-term trends. • aid the design of field sampling program by identifying suitable chemical tracers to target in field sampling and expected mixing zones.	Annually Tests to coincide with WET testing Upon significant changes to the PW stream (Refer to Table 10-10)	Specific analyses, sample collection methods and storage times will be confirmed with a certified laboratory undertaking analyses. Where substantial chemical changes occur, these will be investigated for impact on effluent density, which may decrease mixing, and WET test toxicity.	There are no thresholds for action in carrying out PW Chemical Characterisation as it will always be done in conjunction with WET testing which has thresholds for further action attached to it.

PW WET Testing

Table 10-7: Summary of PW WET Testing

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
PW WET Testing	Determine if predicted impacts are within the mixing zone set for PW and monitor changes in toxicity through time.	Commence within 18 months of startup, then 6 monthly for first 18 months, then triennial thereafter. Upon significant changes (Refer to Table 10-10)	WET testing is done for the direct toxicity assessment of the whole PW effluent in order to allow for the assessment of additive effects from different chemicals and constituents. This is carried out using recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000) in a NATA accredited laboratory. WET testing results may be used to derive more relevant site-specific thresholds for species protection, than the full suite of contaminants outlined in Table 10-6 for water quality. Testing on a full suite of species (minimum of five) for the initial two sampling occasions, then suite reduced to a minimum of two species for succeeding samples in first 18 months of the sampling regime. Full suite of species (minimum of five) will be conducted for each triennial sampling event thereafter.	Dilution targets from the RPS model used to establish the Mixing Zone will be investigated after each round of WET testing, to determine performance against the Target and manage if necessary, following an assessment of the 'representativeness' of the effluent tested. The Target (mixing zone extent based on dilution contours and 95% species protection concentration) will be modified based on a rolling average of the 95% species protection concentration from the three most recent, and representative, WET test rounds. The WET testing data would be extrapolated against the model to determine the number of dilutions required to achieve 95% species protection levels 95% of the time. If this result showed that the ANZECC/ARMCANZ 95% species protection levels were being exceeded more than 5% of the time beyond the predicted mixing zone, additional management measures would be considered. WET test results will be combined with the PW characterisation to investigate the chemical basis of effluent toxicity using such methods as generic environmental hazard evaluation based on chemical composition or Toxicity Identification Evaluation to understand drivers and identify possible mitigations. Changes (increased toxicity that results to mixing zone larger than predicted) in reduced suite of toxicity tests would trigger testing with full suite and chemical characterisation analyses if results were from the reduced WET testing suite. If the WET testing evaluations show that the discharge thresholds are potentially being exceeded at the edge of the predicted mixing zone, an investigation as to the cause of the higher than expected toxicity will be undertaken to determine likely causes and available management options: • Understand the magnitude of likely exceedance (via interrogation of the verified dispersion model) and check if

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
				it is greater than the impact footprint (mixing zone) predicted in the EP. • Understand what is leading to the increase in toxicity (through analysis of operating conditions and interrogation of the WET testing and chemical characterisation results to understand the likely major contributors to overall toxicity).

Field Monitoring

Table 10-8: Summary of the routine/planned infield monitoring campaigns

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
Water Column Sampling[1]	Determine if the PW model is conservative or not (i.e. confirm the model underestimates the actual level of dilutions at the edge of the mixing zone).	One planned routine sampling event within the 5-year validity period of this EP.	Specific sampling locations, contaminants, sample collection methods and storage times will be confirmed with the environmental consultants designing the programme. There will be an initial need to confirm trajectory of the discharge to ensure sampling is occurring within the plume. This may be achieved by visual assessment, remote sensing or real time sensors deployed from vessels running transects, injection of dyes or other methods and will also help identify potential co-mingling zones. Given the FLNG weather vanes and orientation is predominantly influenced by the currents, discharges will typically flow along the hull towards the stern and away from the facility. Along this bow to stern gradient, different discharges can comingle and mix with discharges entering from upstream (for assessment of potential comingling liquid discharge plumes). The spatial separation and different chemistry of the various discharges enables the dilution of individual discharges as well as comingling of multiple discharges to be investigated. Sampling will occur at optimised locations along this gradient with precise	If results indicate the PW model is not sufficiently conservative, a new more accurate model will be established to determine with higher confidence if the PW is meeting compliance/non-compliance at the edge of the mixing zone for PW with WET test results and relevant ANZECC guidelines (95% species protection limits, 95% of the time).

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
			locations adjusted to match the predicted levels of dilutions and proximity of the specific discharges relative to each other. Each water sample will be analysed for the full suite of measured contaminants to determine dilution of PW as a single waste stream as well as to assess the influence of comingling of different discharge streams on the PW plume. Sampling should be conducted within a single tidal cycle at a time of reasonable tidal flow and when thrusters or wind are not holding the FLNG against the tide. Under most conditions discharges are likely to flow along the hull of the FLNG towards the stern, restricted to a small distance laterally from the hull. Along this bow to stern gradient, different discharges are added and mix with any discharges entering from upstream.	

1 – As further detailed in Section 9.9, routine monitoring of sediment quality and benthic habitats will not be undertaken for the duration of this EP due to no credible impact pathway or no environmental effects or damage predicted.

PW Model Verification

Table 10-9: Summary of the PW Model Verification

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
PW Model Verification	Verify through field sampling and observation that topside monitoring combined with the modelling predictions provides a conservative prediction of the extent of the mixing zone for PW discharges	One planned model verification event within the 5-year validity period of this EP.	Initially dye studies, or other suitably robust method, will be used to confirm the trajectory of discharges and, the spatial pattern of dilution and co-mingling of discharges. This may be achieved by visual assessment, remote sensing, real time sensors deployed from vessels running transects, injection of dyes or other methods and will also help identify	Validate model predictions on mixing and/or adjust model to align with measured dilution. Confirm individual mixing zones and extent of co-mingling of different mixing zones (if reasonably practicable) Identify the relationship of the Target Dilution derived from WET testing with ANZECC guidelines for individual chemicals (95% species protection limits, 95% of the time)

Study/Activity	Objectives	Timing	Details of Study/Activity	Thresholds/Further actions
			co-mingling zones as a secondary objective.	If results of the PW Model verification indicate the PW model is not sufficiently conservative, a new more accurate model will be established to determine with higher confidence if the PW is meeting compliance/non-compliance at the edge of the mixing zone for PW with WET test results and relevant ANZECC guidelines (95% species protection limits, 95% of the time). This would also trigger review of the PW impact assessment and assessment under the Shell MOC Manual as applicable to determine if any changes in the impact profile are significant.

PW Changes Requiring Additional Assessment

In addition to the routine/planned monitoring activities outlined in Table 10-4 to Table 10-9, this adaptive management framework also contains potential triggers for additional studies/verification when there are significant changes to the PW discharge characteristics.

Additional studies may be in the form of desktop analysis, modelling studies, additional chemical characterisation and/or WET testing and monitoring of the receiving environment. If the assessment shows a potentially significant increase in the environmental impact consequence ranking, then further corrective and/or contingency actions may be required to ensure impacts are reduced to ALARP and acceptable levels. Potential triggers for additional studies associated with PW changes are presented in Table 10-10.

Table 10-10: Prelude PW Discharge Additional Studies Triggers Due to Potential Changes

Potential Changes	Triggers	Planned Verification Actions
Significant change to chemical additive profile	Change in process chemicals (increase in chemical concentration/dosing above the design envelopes or impact profile of chemicals proposed)	Changes to production or process chemicals are assessed in accordance to the Shell Australia Chemical Management Process (Section 10.1.10). If there is identified increase in environmental impact, additional desktop analysis (e.g. modelling study) and/or WET testing or chemical characterisation may be conducted. Active constituents of the process chemicals may also specifically be added to the topsides monitoring program if practicable.
Change in PW source characteristics	PW (formation water) comes into Prelude from a different reservoir.	If there is a change in reservoir characteristics (new wells or new reservoir), desktop analyses will be undertaken. If desktop analyses indicate potential increase in environmental risk, further characterization or toxicity assessments are conducted to verify environmental impacts.
	Increase in discharge rate or reservoir water cut from maximum design basis of the PW system (165m3/hr discharge capacity)	If there is increase from maximum design basis of the PW system (165m3/hr) in the discharge rate, desktop analysis (including extrapolation from results of existing modelling studies) or additional dilution modelling is done to predict if the increased discharge rate exceeds the required dilution to meet acceptable concentration levels at the edge of the mixing zone.

Changes to the Adaptive Monitoring and Management Framework

Any proposed changes to the Adaptive Monitoring and Management Framework given it is a part of the broader LDMMP will be updated in line with the Shell document management system requirements.

10.4.3 Marine Vessel Assurance

All marine vessels which are planned to be used within the Operational Area are required to achieve "Positive Vetting" in accordance with the requirements specified in the HSSE & SP Control Framework – Transport Manual - Maritime Safety. Numerous assurers are required in order to assure a positive vetting, including Marine SME, Aviation SME and country security manager, Global Maritime Marine Warranty Surveyor and the project workstreams responsible for the particular activity to be conducted. The Marine Vessel Assurance process ensures that the physical safeguards are robust, including:

- Navigation Equipment and Aids
- Communication Equipment
- Dynamic Positioning System
- Lifting Equipment
- Emergency shut-down, alarm and lighting systems.

OCIMF OVID is the basis for all support vessel vetting. Additionally, vessels are screened for class and port state control infractions.

Offtake tankers are positively vetted against the OCIMF inspection.

The following compliance are required for "Positive Vetting" for vessel operating in the Prelude field, excluding equipment and material transportation vessels.

11.4.2.1 Marine Warranty Survey

All vessels and activities are assessed by the Marine Warranty Surveyor (MWS) on behalf of Shell's underwriter. Where required by the Marine Warranty Surveyor (MWS) and in accordance with Construction All Risk (CAR) insurance rules, a marine vessel inspection/suitability survey is performed and a Vessel Suitability Report issued by the MWS with all significant actions and findings closed.

11.4.2.2 Pre-Mobilisation Inspection Report

The Pre-Mobilisation Inspection is conducted to ensure compliance with HSSE, marine and technical requirements and readiness prior to commencing work. Vessels (inclusive of their equipment, processes and procedures) are thoroughly inspected and the inspection report items are closed prior to completion of mobilization.

11.4.2.3 Shell Aircraft International (SAI) Approval

The Shell Aircraft International (SAI) approval ensures that all helidecks on any selected marine vessels utilized for personnel transport are approved. Furthermore, helicopters and helicopter refuelling equipment are approved by SAI.

11.4.2.6 Group Maritime Assurance System (GMAS) Clearance

A GMAS clearance from the Shell Marine SME must be obtained prior to the commencement of marine operations on the Project and prior to the contracted marine vessel entering the Operational Area. This ensures that the above marine vessel assurance has been completed satisfactorily.

10.4.4 Environmental Assurance

Shell’s and contractor’s HSSE Plans make provisions for monitoring, audits and review. Annual HSSE Plans identify environmental audits and reviews that are to be conducted for the year. These audits and reviews include internal and external audits, contractor HSSE audit, waste management audit/review, gap analyses against HSSE Control Framework Manuals, and compliance audit against this EP. An annual internal environmental audit is planned for the Prelude FLNG facility. The frequency of the audit will be reviewed during the annual HSSE Planning.

Shell Group audits are undertaken across all Shell businesses on an intermittent basis. This auditing process assures the HSSE & SP management system as a whole.

The outputs of the audits and reviews are the corrective actions that feed the improvement process. Close-out of these corrective actions is monitored and reviewed.

Regular onsite HSSE assurance is conducted on a weekly basis which includes checking that environmental controls are implemented. Any specific environmental issues, like any HSSE issues, identified during these assurance checks are raised in the HSSE Leadership and Assurance meeting and resolved as part of continually reducing the risks to ALARP and Acceptable levels.

10.4.5 Management Review of Environment Plan

A review of the EP is to be done on an annual basis which will include review of the risk ranking of environmental impacts, effectiveness of controls, relevant records required as evidences of compliance, compliance issues and progress of any actions required to address any compliance issues. The annual HSSE Management System Review includes Environment and identifies areas of concern and improvement at a management system level which outputs the following year’s HSSE Improvement Plan.

10.4.6 Management of Incidents and Non-Conformances

All Health, Safety, Security and Environmental incidents and non-conformances are managed in accordance with the Shell Australia HSSE Incident Reporting, Investigation and Follow up Procedure (HSE_GEN_000027) that describes the process of reporting, classification, investigation, follow-up and close out. Non-conformances are treated in the same way as incidents and for the purposes of this document are referred to as incidents.

All incidents records are managed in an online electronic system called Fountain Incident Management (FIM). Below is the overview of the incident management process:

- The system allows incidents to be raised by any employee of the company including offshore personnel.
- The incident is then assigned to a Responsible Supervisor (Incident Owner) who then retains the ownership of the incident until closeout.
- The Responsible Supervisor initiates the Incident Investigation the depth of which depends on the actual and potential risk ranking of the incident.
- The recommendations of the investigation team are reviewed by the Incident Owner who then assigns the corrective and preventative actions to the appropriate action party. Actions are tracked to closeout where the Incident Owner accepts that the remedial action is successfully completed based on the evidence recorded and logged in FIM.

- FIM provides functionality for automatic reminders for Incident Owner and Action Parties about the actions due. However, in addition reviews of outstanding actions are carried out both at asset/department level, and at the Shell Business Assurance Committee level at regular intervals to ensure timely closeout of actions.

All employees or contracted staff are encouraged to submit incident reports to alert the organisation about the occurrence of an incident or non-conformance.

In addition to the Incident Management Process outlined above, Shell also reports the number of non-compliances (incidents/ non-conformance) to the Shell Group on a quarterly basis, along with other HSE data in accordance with Shell Group Performance Monitoring and Reporting (PMR) standard. This information is reviewed in a dedicated HSE Business Performance Review where Shell Australia performance is reviewed by the Shell Group.

The incident investigation process works to understand the cause of an incident and the reason why a control/ mitigation measure has failed and to rectify the fault to prevent recurrence and the reporting process works to track performance and allows sharing of learnings. This process contributes to reducing the risks to ALARP and Acceptable Levels.

10.5 Reporting

10.5.1 Annual Environmental Performance Reporting

Regulation 14(2) and 26C requires that an Environmental Performance report will be submitted to NOPSEMA in intervals not more than 1 year. Annual Environmental Performance Reports will contain a full year (1 July – 30 June the following year) and will be submitted to NOPSEMA by 31 December.

Shell is also required to report annual greenhouse gas emissions and energy usage and pollutants emissions under the National Greenhouse Gas and Energy Reporting (NGER) Scheme and National Pollutant Inventory (NPI) reporting, respectively. The reporting period for these also cover a full year (1 July – 30 June the following year).

10.5.2 External Incident Reporting

Reportable Incidents

NOPSEMA will be notified of all reportable incidents under Regulation 26 of the OPGGS (E) Regulation within two hours of the incident and in writing within three days. Under the OPGGS (E) Regulations, Reportable Incidents are defined as *'an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage'*. The Shell Risk Assessment Matrix (refer to Section 9.2) uses severity levels 0 to 5 to define environmental consequences (no effect, slight effect, minor effect, moderate effect, major effect and massive effect'). All environmental effects with a severity 3 or greater (i.e. moderate to massive) are considered Reportable Incidents. Based on the risk assessment (Table 9-32 and Table 9-71), five events are considered to be of moderate or higher consequence:

- Any confirmed introduced marine pest species in Australian waters attributable to the petroleum activities
- Diesel spill resulting from a collision with another vessel
- HFO spill due to rupture of storage tank of a product offtake tanker

- Condensate spill due to rupture of storage tanks on the FLNG as a result of breach of the hull
- An uncontrolled hydrocarbon release from the wellhead similar to a well blow-out.

The reportable incident report contains all material facts and circumstances concerning the reportable incident, actions taken to avoid or mitigate any adverse impacts and corrective action taken. This report will be made to NOPSEMA.

Recordable Incidents

Recordable incidents in the OPGGS (E) Regulations are defined as *'an incident arising from the activity that breaches a performance objective or standard in the Environment Plan that applies to the activity and is not a reportable incident'*.

NOPSEMA will be notified of all Recordable Incidents, according to the requirements of Regulation 26B of the *OPGGS (E) Regulations*. A report of Recordable Incidents must be given to NOPSEMA *'as soon as practicable after the end of each calendar month, and in any case not later than 15 days after the end of the calendar month'*.

As per the OPGGS (E) Regulations, the report will comprise:

- *'A record of all Recordable Incidents that occurred during the calendar month*
- *All material facts and circumstances concerning the Recordable Incidents that the operator knows or is able, by reasonable search or enquiry, to find out*
- *Any action taken to avoid or mitigate any adverse environment impacts of the Recordable Incidents*
- *The corrective action that has been taken, or proposed to be taken, to prevent similar Recordable Incidents'*.

Other Externally Notifiable Incidents

Other externally notifiable incidents are captured in Table 10-11.

Table 10-11: Other Externally Notifiable Incidents

Incident	Legislation	Timing of Notification with respect to the occurrence of the incident.	Contact Details
Any breach in the quarantine regulations, including exchange of ballast water within the twelve nautical mile limit.	Biosecurity Act 2018, Australian Ballast Water Management Requirements 2017.	As soon as practicable	Department of Agriculture (Maritime National Coordination Centre) Phone: 1300 004 605
Any confirmed introduced marine pest species in Western Australian state waters.	Fish Resources Management Regulations 1995 r176(1)	Within 24 hours.	DPIRD FishWatch 1800 815 507 Email: aquatic.biosecurity@dpird.wa.gov.au

Incident	Legislation	Timing of Notification with respect to the occurrence of the incident.	Contact Details
			Aquatic Pest Biosecurity Section: 08 9203 0111
Death or injury of threatened, migratory or cetacean species from collision with a vessel.	EPBC Act 1999, Chapter 5, Part 13, Division 3, subdivision C, 232 (2).	Within 7 days, including the time, place, circumstances, species affected and the consequences of the action.	The Secretary, DoEE

10.5.3 Internal Reporting

Shell also has internal reporting requirements against environment parameters identified in the Shell Group Performance Monitoring and Reporting (PMR) standard. This data is used as the basis for an annual Shell Group Sustainability Report.

10.5.4 Notifications

Start and end of an activity

In accordance with Regulation 29, Shell will notify NOPSEMA and DMIRS of the commencement of the Petroleum Activities Program at least ten days before the activity commences, and will notify NOPSEMA and DMIRS within ten days of completing the activity.

Notification of the end of the Environment Plan

The EP will end when Shell notifies NOPSEMA that the Petroleum Activities Program has ended and all of the obligations identified in this EP have been completed, and NOPSEMA has accepted the notification, in accordance with Regulation 25A of the OPGGS (E) Regulations.

10.5.5 Details of Titleholder and Liaison Person

In accordance with Regulation 15 of the OPGGS (E) Regulations, details of the titleholder, liaison person and arrangements for notifying of changes are described below.

Titleholder:

Shell Australia Pty. Ltd. (ACN/ABN: 009663576/14009663876)

562 Wellington Street, Perth 6000 WA

Activity Contact:

Sue Beattie

Prelude FLNG Asset Manager

Email address: SDA-preludeflng@shell.com

Contact numbers: 1800 059 152

Should the titleholder, titleholder's nominated liaison person or the contact details for either change, NOPSEMA is to be notified in writing of the change within two weeks or as soon as practicable.

10.6 Record Keeping

Compliance records will be maintained. Record keeping will be in accordance with OPGGS (E) Regulation 14(7) that addresses maintaining quantitative records of emissions and discharges which is accurate and can be monitored and audited against the environmental performance standards and measurement criteria.

10.7 Maintenance and Testing of Emergency Response and Oil Pollution Emergency Plan

The Prelude Oil Pollution Emergency Plan (OPEP) (HSE_PRE_013075) is presented in a standalone document. The OPEP and associated plans and procedures will be tested prior to and during the prelude FLNG operations, to make all personnel aware of their responsibilities in the OPEP (refer to the OPEP for details).

Exercises are critical to ensure there is appropriate level of response readiness should there be an incident and is an important part of continually managing the risks associated with an oil spill to ALARP and acceptable levels.

The following exercises are planned for:

- One exercise prior to the commencement of the installation, hook-up and commissioning activities - a walk-through of the OPEP by the ERT to test the communication, ERT functionality, Emergency Response Plans with Technip's interaction, and to ensure that the Emergency Response Team members are aware of their roles and responsibilities in the event of an incident.
- One test during the hook-up and commissioning phase to test the interaction between the vessel, Technip and Shell's IMT.
- Develop and implement an annual emergency exercise and drill schedule which shall include testing of all elements an oil spill response. Not every element will be tested every year however, elements to be tested shall include:
  - An annual oil spill exercise during the operations phase to test communications and functionality of the OPEP
  - Exercising people's ability to deploy spill response equipment
  - Exercising interface between ERT and IMT
  - Exercising the logistics functioning and capacity against that described within the OPEP
  - Exercise stand-up of relevant OSMP sections implementation
  - Exercise oil spill monitor and evaluation tactics.
- Shell participation in national plan exercises coordinated by AMSA or AMOSC or NOPSEMA.
- Industry participation and shared learnings of annual (if any) exercises which include a DOT interface/transition.
- Participation in the Shell Global Response Network annual Tier 3 exercise which aims to test the functionality of Shell Group's Tier 3 oil spill response capabilities.

10.7.1 Mechanism to examine the effectiveness of the response arrangements against the objectives of testing

Objectives for spill exercises will be SMART for Level 1, 2 or 3. This will enable the objectives to be clearly evaluated as being met or not. An independent assessor (either internal or external) will examine the effectiveness of the response arrangements during a spill exercise to determine the outcome of the objectives. The assessor will make written findings and recommendations from the test for consideration by Shell to assist in identifying deficiencies with response arrangements and continually improve the overall response readiness of Shell.

Recommendations from the tests will have SMART actions put against them where appropriate and they will be tracked to closure in Shell's action tracking system.

11.0 References

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List of Acronyms

Acronym	Definition
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHTS	Anchor Handling Tug Supply Vessel
ALARP	As low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
APPEA	Australian Petroleum Production & Exploration Association Limited
AusSAR	Australian Search and Rescue
Bbl	Barrels
BIAs	Biologically Important Areas
BOP	Blowout Preventer
BTU	British Thermal Unit
CAMBA	China-Australia Bilateral Agreement on the Protection of Migratory Birds
CHARM	Chemical Hazard Management Risk Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSIRO	Commonwealth Scientific and Industrial Research
CTA	Cable Termination Assembly
DAFF	Department of Agriculture, Fisheries and Forestry (now known as the Department of Agriculture, Water and the Environment)
DAWE	Department of Agriculture, Water and the Environment
DEWHA	Department of Environment Water Heritage and Arts (formally DEH, Department of Environment and Heritage)
DMIRS	Western Australia Department of Mines, Industry Regulation and Safety
DPIRD	Department of Primary Industries and Regional Development
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now, Department of Environment or DoE)
EAAF	East Asian-Australasian Flyway
EEZ	Exclusive ecnomic zone
EGR	External and Givernment Relations
EIS	Environmental Impact Statement
ENVID	Environmental Risk Identification
EP	Environment Plan

EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
ERP	Emergency Response Plan
ESD	Emergency shut down
FID	Final Investment Decision
FIM	Fountain Incident Management
FLNG	Floating Liquefied Natural Gas
HFO	Heavy Fuel Oil
HLIV	Heavy Lift Installation Vessel
HOCNF	Harmonized Offshore Chemical Notification Format
HSE	Health, Safety and Environment
HSSE and SP	Health, Security, Safety, Environment and Social Performance
IOPP	International Oil Pollution Prevention
IMO	International Maritime Organisation
IMS	Invasive Marine Species
ISVs	Infield Support Vessels
IPEICA	The International Petroleum Industry Environmental Conservation Association
JAMBA	Japan-Australia Bilateral Agreement on the Protection of Migratory Birds
KEFs	Key Ecological Features
LWI	Light well intervention
MAE	Major Accident Events
MARPOL	The International Convention for the Prevention of Pollution from Ships, adopted by the International Conference on Marine Pollution, convened by IMO, 1973/78.
MEG	Mono-ethylene Glycol
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MNES	Matters of National Environmental Significance
MOPO	Manual Of Permitted Operations
MOU	Memorandum of Understanding
MPV	Multi-Purpose Vessel
MS	Management System
MSL	Mean Sea Level
NGO	Non-Government Organisations
Nm	Nautical mile
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOx	Nitrogen oxides
NT	Northern Territory

NWS	North West Shelf
OCNS	Offshore Chemicals Notification Scheme
OGP	Oil and Gas Producers
OIM	Offshore Installation Manager
OPEP	Oil Pollution Emergency Plan
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPRC 90	International Convention on Oil Pollution Preparedness, Response and Cooperation 1990
OSPAR	Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbon
PLET	Pipeline End Termination
POB	Persons on Board
ROV	Remotely Operated Vehicle
ROKAMBA	The Republic of Korea Migratory Birds Agreement
Shell	Shell Australia Pty Ltd
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities
SG	Specific gravity
SIMOPs	Simultaneous Operations
SOPEP	Shipboard Oil Pollution Emergency Plan
SO_2	Sulphur Dioxide
Technip/TPO	Technip Oceania Pty Ltd
UTA	Umbilical termination assemblies
WA	Western Australia
XT	Xmas tree for wellheads
ZPI	Zone of potential impact

12.0 Appendix A: Detailed Facility Description

12.1 Gas Process Facilities

Feed from the turret enters feed gas receiving and condensate stabilisation (Unit 10000). The gas, condensate and water phases are separated in two trains of inlet HP separators and one low pressure separator. The aqueous phase is routed for processing either in MEG regeneration (Unit 52000) or water treatment (Unit 64000). The separated field condensate is stabilized in the condensate stabilizer and sent to condensate storage (Unit 33000). The separated gas is routed to the Acid Gas Removal Unit (AGRU, Unit 11000). The feed gas receiving unit is also provided with depletion compression facility to compress the inlet gas once the reservoir pressure is reduced.

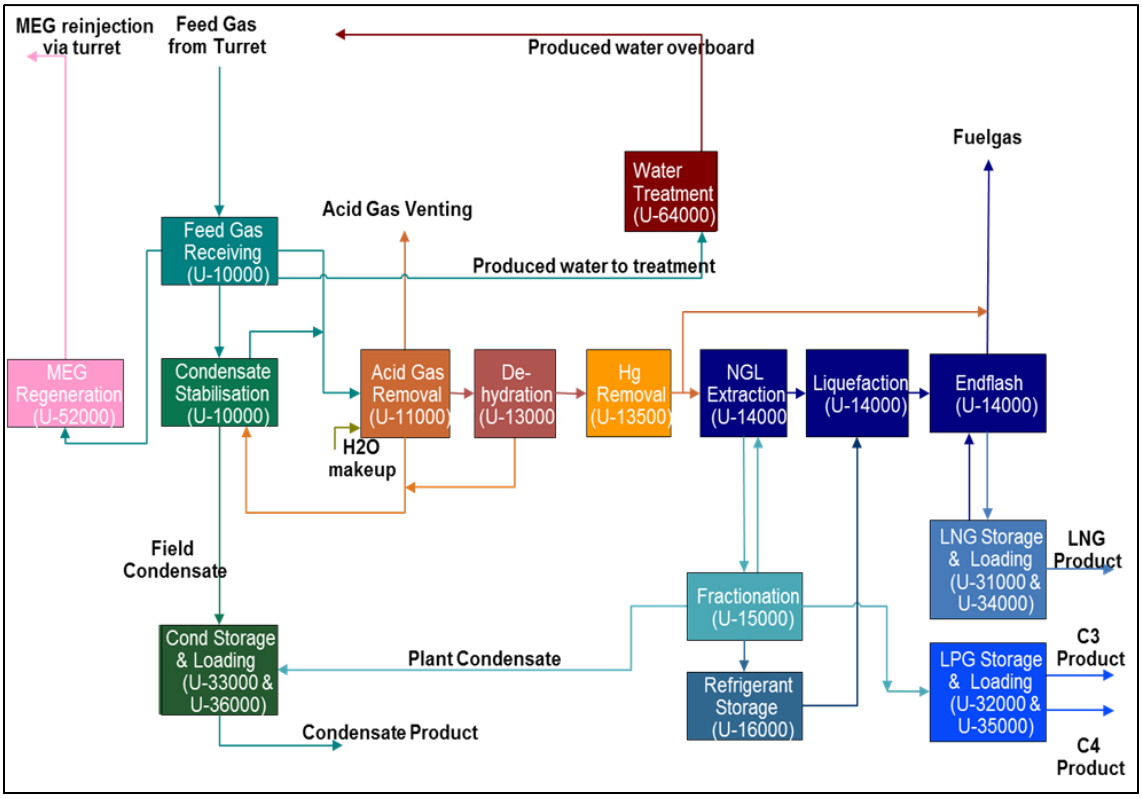


Figure 12-1: FLNG Process Unit Block Diagram

The AGRU removes the acid gases (CO_2, traces of H_2S and mercaptans) from the feed gas by contact with a lean amine based solvent stream. The resulting rich amine is then regenerated and the separated CO_2 rich acid gas stream is routed for safe venting. The sweet gas passes through the dehydration (Unit 13000) unit for removal of moisture and mercury removal (Unit 13500) unit for removal of mercury. The sweet, dry and impurity free gas then enters Unit 14000 consists of NGL extraction, liquefaction and end flash.

Natural Gas Liquid (NGL) within the feed gas stream is separated in the NGL extraction column. The separated NGL is routed to Unit 15000, fractionation, and the natural gas is sent to the liquefaction section of Unit 14000. The natural gas is pre-cooled and then liquefied using closed loops of pre-cooled mixed refrigerant (PMR) and mixed refrigerant (MR). The produced LNG is let down to close to atmospheric pressure in a turbo expander, before being routed to an end flash column. The resulting atmospheric LNG stream is gravity rundown to storage in Unit 31000 and the end-flash gas produced is compressed for use as fuel gas (Unit 44000).

Within the fractionation Unit 15000, the NGL is separated into ethane, propane, butane and condensate streams. The ethane stream is either: re-injected into the liquefaction unit, routed as vapour for use as fuel gas, or stored in refrigerant storage tank in Unit 16000 as a make-up to the refrigerant loop. Commercial grade propane and butane are produced and routed to LPG storage in Unit 32000. Provision is made to re-inject LPG to liquefaction unit as required. Pure Propane is stored in dedicated refrigerant storage tank in Unit 16000 as a make-up to the refrigerant loop. The plant condensate stream produced from the fractionation unit (U15000) is combined with the field condensate from Unit 10000 and routed to condensate storage Unit 33000. LNG and LPG products are offloaded to ship tankers by side by side offloading in Unit 34000 and 35000, whereas the produced stabilized condensate is offloaded tandem to the condensate tanker by using hose reel in Unit 36000.

The majority of the process facilities are located on the topsides, with some facilities such as tank storages and loading pumps located within the substructure.

12.2 Pressure Relief System

The purpose of the pressure relief and liquid disposal systems (U63000) is to collect and safely dispose of hydrocarbon-containing vapour and liquid streams that are released during start-up, shutdown, venting, draining, upsets, maintenance and emergency situations. The pressure relief system composes of:

- **Dry Flare System** - comprising of a HP system which protects primarily process equipment and a LP system which provides relief for storage tanks.
- **Wet Flare System** - comprising of a HP system which protects primarily process equipment and a LP system which provides relief for storage tanks.
- **Acid Gas Vent** - where CO_2 extracted from the gas is vented to atmosphere.
- **Marine Vent** - final pressure protection for the condensate and cryogenic tanks. It is not expected that significant GHG emissions will be emitted from the Marine Vent which has a flow meter.
- **Maintenance Vent -** final pressure protection for the condensate and cryogenic tanks during maintenance activities on the flare system. The maintenance vent is located in a different area to the main flare, to allow for safe maintenance on the flare system in the event of a gas release through the maintenance vent. The maintenance vent is also used during maintenance of the tanks (e.g. warming up, purging, aerating and gassing-up procedures). It is not expected that significant GHG emissions will be emitted from the Maintenance Vent which has a flow meter.

12.3 Steam, Power Generation & Condensate Recovery

Prelude Steam and Power Generation and Distribution design is based on a steam cogeneration system to supply services to the FLNG facility at the required quality, availability and reliability during all operation modes. Since the plant is an offshore unit, the power generation system is based on a stand-alone operation. The purpose of Steam and Power Generation and Distribution System (Unit 40000) is to generate electricity in the plant and supply heat in the form of steam to generate power.

Prelude total design power requirement is 74.9 (64.9+10) MW including the thrusters. Total design steam requirement is around 1300 tons/hr. Based on this total, 7 (6+1) steam generator boilers are installed on the topsides, each with a Maximum Continuous Rating (MCR) of 220 tons/hr capacity. The main electrical power generation is produced by 3 (2+1) steam turbine generators of 40 MW Extraction/Condensing Steam Turbines. Steam turbine generators are supplied with HP Steam directly from Marine Steam Boilers to produce electricity for all the process and non-process electrical consumers.

In addition to the main power generation, three Essential Marine Diesel Generators (EDG), (3 x 7.68 MW), are on stand-by during normal operations. The function of these EDGs include providing power to critical instrumentation load during process shut down.

Emergency power is provided by two SOLAS designated emergency generator sets (A-40210) having capacity 1250kw, located aft, supplemented by (A-40220) emergency generator having capacity 750kw, located forward for secondary refuge power.

Autonomy of the Emergency power generator is 24hr in accordance with SOLAS requirements in order to supply electricity to SOLAS critical equipment (e.g. control and safety systems, Navigational aids, Communications used in emergency, Emergency lighting; and Fire-fighting foam pumps).

In addition, uninterruptible power supply (UPS) supplies for a limited amount of time systems such as the DCS, HVAC system, telecommunications, navigational aids or other vital systems.

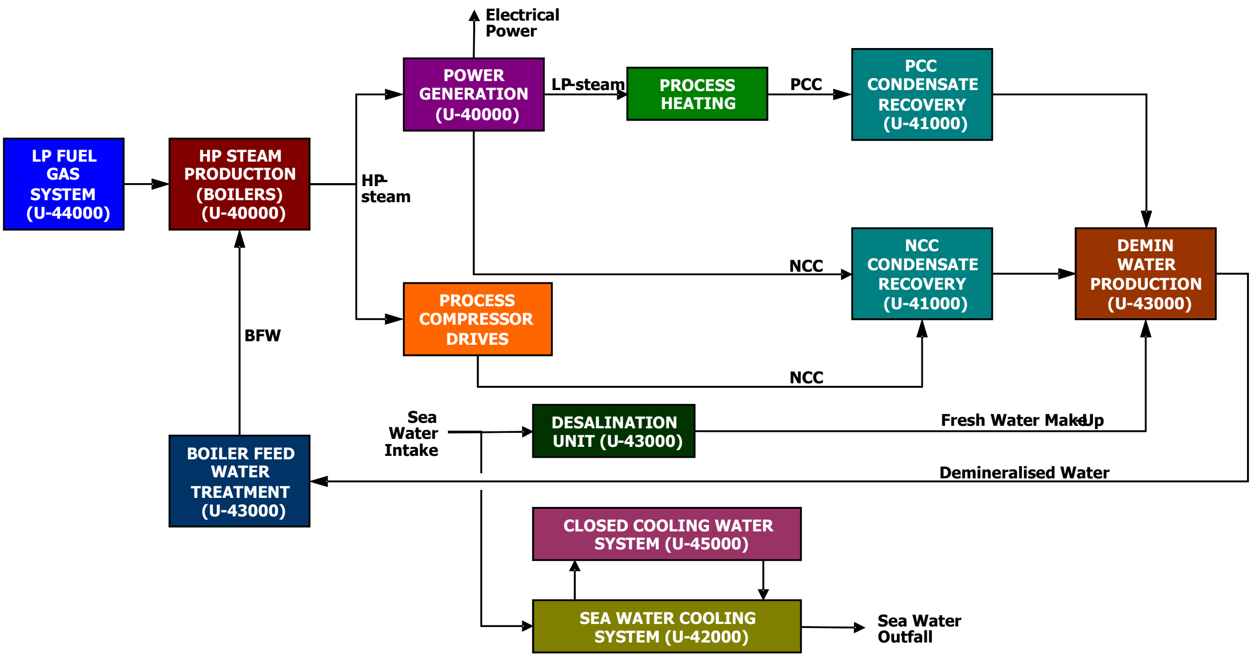


Figure 12-2: Prelude Utility Concept and Block Scheme

Fuel Gas System

Fuel Gas System Unit U-44000 is designed to collect different sources of process gases, to heat them via heater and mix them in order to supply fuel gas to identified consumers at defined pressure, temperature, flow rate and quality (wet or dry). In order to improve the reliability and availability of the fuel gas to consumers, several sources of process gas are provided to the unit with available back-up sources. Dry fuel gas is used as purge to dry flare and blanketing of LNG/LPG tanks. Whereas the mixed fuel gas is used for the boilers, purge to wet flare and blanketing of condensate tanks.

Total fuel gas design demand for Prelude is about 97tons/hr corresponding to the total required HP steam production for the operation of 6 boilers. In addition to fuel gas requirements for steam boilers, 80kg/hr of continuous fuel gas is accounted for all flare pilot burners consumption.

Diesel System

Diesel fuel is used for backup power generation in case of non-availability of fuel gas. The design of the diesel oil system includes receipt through diesel bunker, store, treat and distribute low sulphur diesel oil to various consumers in the Hull and Topsides and to occasionally refuel the supply boats.

Diesel fuel is transported by a supply boat and transferred through hose reel (or alternatively through a secondary diesel oil loading station located at the aft deck boarding) via the diesel filter and a bidirectional metering unit to the storage tanks.

Four diesel storage tanks, each with 750m^3 storage volume have been provided for diesel storage in the FLNG's substructure. The Essential diesel generators, aft fire water pump and aft emergency diesel generator have their own day storage tanks. Similarly, the forward Emergency diesel generator and forward fire water pump have their day storage tanks for storing the diesel oil.

12.4 Seawater Cooling & Essential Seawater Cooling System

The Sea Water Cooling Systems 2, 3 and 4 (U42000) and Essential Sea Water Cooling System 1 (U42500) are to provide sea water for cooling of the following systems:

- Essential Diesel Generators Closed Cooling Water loops, by Essential Sea Water Cooling System 1 (SW1)
- Closed cooling water 2 loop, by Sea water cooling system 2 (SW2)
- Closed Cooling Water 3 loop, by Sea Water Cooling System 3 (SW3)
- Steam Turbine Generators condensers, by Sea Water Cooling System 4 (SW4).

The purpose of the Essential Closed Cooling Water System 1 (CCW1) is to provide the continuous cooling water to the Essential Diesel Generator packages. The purpose of Closed Cooling Water System 2 (CCW2) is to provide cooling water for cooling requirement of the topsides process users of the FLNG facility. The purpose of Closed Cooling Water System 3 is to provide the cooling requirement of HVAC, IA compressors and dryers, hydraulic power units, electrical users, STG auxiliaries, thrusters, steam/condensate system users, and HP Nitrogen Compressor.

12.5 Water Distillation

The purpose of Seawater Distillation, Service Water, Potable Water, Demineralisation Water Storage and Boiler Feed Water Facilities (Unit U43000) is:

- To supply water in the form of:
  - Potable Water to its respective users
  - Service Water for utility stations and hose connection
  - Make-up water for steam and condensate systems losses and for mixed beds
  - Regeneration.
- To treat Potentially Contaminated Condensate with Heavy Hydrocarbons (PCH).
- To supply de-mineralized water (DMW) to its respective users.
- To supply Boiler Feed Water (BFW) to boilers and de-superheating water to its respective users.

Seawater Distillation

The seawater distillation system removes salts from seawater to produce desalinated water. The produced distillate is then distributed to the service and potable water facilities and as make-up water for replacement of condensate and steam losses.

As the seawater is chlorinated to limit marine growth in the system it must be de-chlorinated prior to entering the distillation units to prevent contamination. The seawater is vaporised and the resulting distillate is cooled and routed to downstream users. The brine produced from the distillation process is routed overboard.

To clean the unit and remove the scale which has not been eliminated by the continuous feed water chemical treatment, an acid cleaning of the unit is performed using a weak acid (sulfamic acid or equivalent). The weak acidic solution remaining after cleaning is sent to the neutralisation tank to be neutralised before being discharged to the sea.

Desalinated water from the distillation unit is re-mineralised in a hardener bed to produce potable water.

Demineralised and Boiler Feed Water Facilities

The demineralised and BFW facilities are provided to generate water with the required specification to allow for HP steam generation. Impure water will cause corrosion and scaling in the steam system and cause unnecessary downstream intervention and maintenance.

Power generation is based on a steam cogeneration system. Electrical power generation is by STGs. Heat is supplied by marine boilers fed with BFW to produce HP steam. The steam is then routed to downstream process and non-process users. The resulting steam condensation are treated to produce demineralised water which is then used as BFW.

To produce de-mineralised water (DMW) of the desired specification, mixed bed exchange polishers (two in operation, one stand-by/regeneration) are provided. The DMW further passes through three spray type de-aerators to produce boiler feed water. The BFW is then pumped to the boilers. BFW is also used as medium for de-superheating and turbine washing. After BFW has been used for boiler operations, boiler blowdown is discharged to sea with flashed steam.

There is a neutralisation tank associated with the mixed bed polisher (MBP) regeneration process, which is a water treatment package prior to being fed into the boiler feed water tank. The MBP regeneration process uses acid (HCl) and base (NaOH) to remove anions and cations from the beads in MBP unit. This regeneration waste liquid is then sent to the neutralisation tank for treatment (‘pH neutralisation’) before being discharged to sea. The neutralisation tank recirculation line and discharge lines also have an online analyser and alarm systems set on them which measures pH.

12.6 Electro-chlorination Unit

The Unit 46000 Seawater Fouling Inhibition is also known as electro chlorination unit. The function of the Electro chlorination unit is to generate, store and inject sodium hypochlorite into following systems containing seawater:

- Cooling sea water circuits to protect equipment against bio-fouling (SW2 intake risers, SW1/SW3/SW4 sea chest intakes)
- Seawater Distillation Packages A-43010/43020/43030 seawater intake
- Firewater pumps P-60001A/B and firewater jockey pumps P-60002/P-63003 circuits
- Diesel firewater pumps P-60000 A/B sea chests.

By using the process of electrolysis of seawater, the sodium hypochlorite required to treat the seawater can be produced from the seawater itself. This is achieved by passing a quantity of seawater through an electrolyser cell and applying a DC current across the cell. The resulting electrolytic reaction produces sodium hypochlorite and hydrogen.

Continually dosing into seawater systems at low concentrations effectively prevents organic and bacteriological (mussels, barnacles and sea anemones) growth which could cause fouling/plugging or corrosion in the system. However over a period of time microorganisms (bacteria, slime and algae) can become chlorine resistant therefore an intermittent (once or twice a day) shock dose at a higher concentrations is required.

Local generation onboard removes the need to import and store large quantities of sodium hypochlorite solution.

12.7 Mono-ethylene Glycol (MEG) System

The purpose of the MEG unit U52000 is to concentrate and reclaim rich MEG coming from Produced Water Treatment Unit (U64000) prior to reinjection into subsea facilities or topsides for hydrate prevention. Lean MEG is injected intermittently to the subsea facilities during following cases. The first four of these cases make up the primary use of MEG during SURU and normal operations:

- Before a planned shutdown
- When plant is down after any planned or unplanned shutdown (at each well)
- During any start-up
- During adverse weather, to pre-treat flow lines in the event of an unplanned shutdown
- During gas sweeping operations (before start-up)

- For well annulus management, during normal operation.

Lean MEG is also injected topsides in the inlet facilities (U10000) for hydrate prevention in the flare lines.

For rich MEG storage, there are two tanks in the substructure with a capacity of 6000 m3 each and one forward rich MEG tank with a capacity of 2000 m3. The MEG regeneration system has a design capacity to regenerate about 30 m3/day at 20 wt % rich MEG.

12.8 Effluent Treatment and Disposal System

Prelude Effluent and Waste Treating and disposal U64000 is divided into three main sections, each with different objectives:

- Degassing section
- Hydrocarbon extraction section, Macro Porous Polymer Extraction (MPPE)
- Disposal section.

The inlet facilities U10000 receive produced water (PW) from production wells. This produced water along with oily contaminated streams from other units is routed to U64000, on either continuous or intermittent basis as indicated below:

Continuous produced water flow is from inlet facilities U10000:

- Produced water from LP separators
- Condensate stabilizer draw vessel.

The following intermittent streams are routed to the water treatment unit:

- Water from sand handling package (A-10010)
- Wash water bleed from AGRU solvent regeneration reflux pumps
- Dehydration unit regeneration water (U13000)
- Contaminated steam condensate from PCL and PCH collection headers (U41000)
- Clean Slop tank
- Produced water from MEG Regeneration and Reclaiming package A-52010.

The degassing section refers to the section between produced water inlet and produced water buffer tank. This first section collects produced water and other effluents from several sources and achieves their degassing, primary hydrocarbon removal and cooling. This section includes Produced Water Flash Gas Package (A-64030), Produced Water Cooler (E-64001A/B/C) and a Produced Water Buffer Tank (T-64001). The inlet produced water streams are first routed to a water flash gas vessel where the pressure is reduced to the LP wet flare operating pressure. This degasses the dissolved hydrocarbon in the produced water inlet streams. The degassed stream is then cooled to 34ºC by the produced water cooler; this is the optimum operating temperature for the downstream Macro Porous Polymer Extraction (MPPE). The water is stored in a buffer tank, before being processed in the MPPE unit.

Pumps from the produced water buffer tank transfer water with traces of hydrocarbon to the hydrocarbon extraction section i.e. the MPPE package (A-64010). One MPPE package (A-64010) is designed to remove dispersed and dissolved hydrocarbons from the water via extraction. After treatment, the treated water is checked to ensure specifications for overboard discharges are satisfied. To meet the oil discharge limit, the MPPE system removes dissolved and dispersed hydrocarbons from the feed water by means of extraction in a MPPE bed.

The unit consists of four columns (two in service: one in extraction mode and one in regeneration mode, and two in stand-by) containing a packed bed of macro porous polymer extraction material which is oleophilic and hydrophobic. Two spared columns located within the package allow for the change-out of the extraction columns for onshore regeneration. Each column will have its installed spared column with a set of manual valves to allow operator manual change over. It runs continuously to treat water from produced water buffer tank. It can also receive off-spec water from Clean Slop tanks via the produced water tank. Clean water from the Slop Tanks is normally discharged overboard to sea under oil in water content monitoring. However, in case concentrations exceed specified discharge limits, the overboard discharge is ceased, and oily water is routed to the Produced water buffer tank after recycle within slop tanks. During the column regeneration phase, very low pressure steam is used to evaporate the components from the macro porous polymer extraction material, resulting in a vapour flow of mixed hydrocarbons and steam. The vapour is routed through a condenser where condensation of both steam and hydrocarbons takes place by cooling with closed cooling water (CCW3). The extracted hydrocarbon (BTEX rich) as a by-product is collected in the overhead vessel, which is pumped back to the hydrocarbon condensate streams at the upstream of rundown cooler in U10000.

The treated water is monitored for oil content and reprocessed if found off-spec. The on-spec water is routed overboard for disposal to the sea.

12.9 Drains

The intent of the drain system is to provide a safe and environmentally acceptable method of collecting and disposing of:

- Cleaning water
- Recyclable liquid hydrocarbons as oily water
- Separately collected “other” liquids handled on the FLNG.

The drain systems are segregated into different zones and separate systems to avoid cross contamination, thus allowing for more efficient, safer spill and drain management taking into account:

- Cryogenic modules and fluids
- Non-Hazardous areas and fluids
- Hazardous areas and fluids.

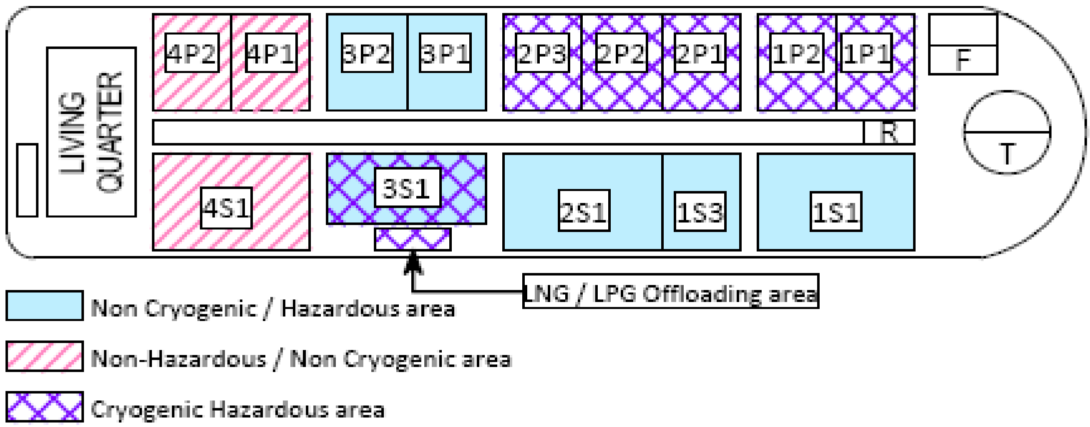


Figure 12-3: Drainage Zone Areas

Open Drains

The open drain system is composed of several segregated sub-systems, each with a different function and hierarchy. The open drains systems (U65000) are used only after unit depressurization for maintenance works and are also used to collect rain water, firewater deluge, washing water and lube oil leaks from drip trays of equipment. The intent of the open drain system is not to collect the liquid products during emptying of the connected hydrocarbon processing system. There is no hard piping connected from process equipment to the open drain system. The open drain material is either treated in effluent water treatment unit or reprocessed in U10000 or stored in dirty Slop/ bilge tank. The open drain systems include the;

- Open Hazardous Drain System (OHD)
- Open Non-Hazardous Drain System (OD)
- Open Chemical Drain System (OCD)
- Open Steam Condensate Drain System (OSD)
- Open Bilge Drain (OBD).

The Open Hazardous Drain system (OHD) and Open Non-Hazardous Drain System (OD), drain headers are sloped towards the respective open drain vessels. The fluids from the drip trays and tundishes are gravity-fed into the open drain vessels where oily water is separated and transferred to the Slop /bilge tanks respectively.

In the hazardous areas drains system, any oil/accidentally oil contaminated water is sent to the Dirty Slop tanks via the Open Hazardous Drain pumps. Oil Discharge Monitoring Equipment (ODME) is provided to monitor oil/condensate content in water before being discharged overboard from Clean Slop tanks. In case of off-spec water stream, the recirculation valve is open to return the off-spec stream back to Dirty Slop tanks, or to MPPE package for treatment. Open non-hazardous area drains are completely segregated from any other open or closed drain system to avoid hydrocarbon vapour transmission from one drain to a nonhazardous one.

The Open Chemical Drain (OCD) system collects chemical spills from open drip trays and tundishes from topsides process modules, main deck and turret area. Drip pans in

U50000 (Chemical Injection), U11000 (Acid Gas Removal Unit) and U52000 (MEG Regeneration Unit) are connected to both the open bilge drain header and open chemical drain header. The chemical spills drain header from hazardous and nonhazardous areas are segregated. The chemical spills drain header from the hazardous areas are sloped towards the Chemical Spills Collection tank. Collected chemicals are pumped via Chemical Spills Collection pump to portable containers (tote tanks) before onshore treatment.

The open steam condensate drain system (OSD) is provided to collect the Steam Condensate from the steam traps of the Steam Turbine, from the drip holes (located on Relief Valve discharge lines), from the silencers lines and from the level instruments.

The Open Bilge Drains System (OBD) covers the open drains facilities on the Main Deck (e.g. Aft/Forward Coamings, exposed deck scupper system, etc.), void space, insulation space (IS), cofferdam (C/D), bunker stations and machinery space. The liquid collected is drained by gravity and discharged closed to pneumatic pumps and then pumped to the dirty Slop Tanks (for hazardous areas) or dirty bilge tanks (for nonhazardous areas). However, the cofferdam bilges is routed to the dirty slop tanks.

Closed Drains

Two closed systems exist for the HC drainage, which divert liquids to the flare system (U63000). These closed drains are used for emptying vessel inventories after depressurisation and prior to maintenance. The closed systems are:

- Closed hydrocarbon Drain (CD)
- Cryogenic Drain (CRD).

All deck areas where there is a risk of cryogenic/LPG spill hazard are freely drained directly overboard. This is to avoid the risk of explosive clouds when cryogenics/LPG spills vaporise. The primary steel structure is protected from cryogenic spills by suitable coatings. Equipment and piping in cryogenic service have minimum flanges and maximum welded connections. However, cryogenic protection on the main deck is provided on location where there is high volume of cryogenic liquid is handled e.g. offloading area, 3S1 based on the cryogenic spill risk assessment.

13.0 Appendix B: EPBC Act Protected Matters Reports

This appendix consists of two reports issed by the Australian Government Department of the Environment and Energy (renamed to Department of Agriculture, Water and the Environment at the time of submission of this EP):

- EPBC Act Protected Matters Report, Report created: 27/02/19 08:09:05 (13 pages)
- EPBC Act Protected Matters Report, Report created: 03/09/19 15:03:57 (33 pages)

Australian Government

Department of the Environment and Energy

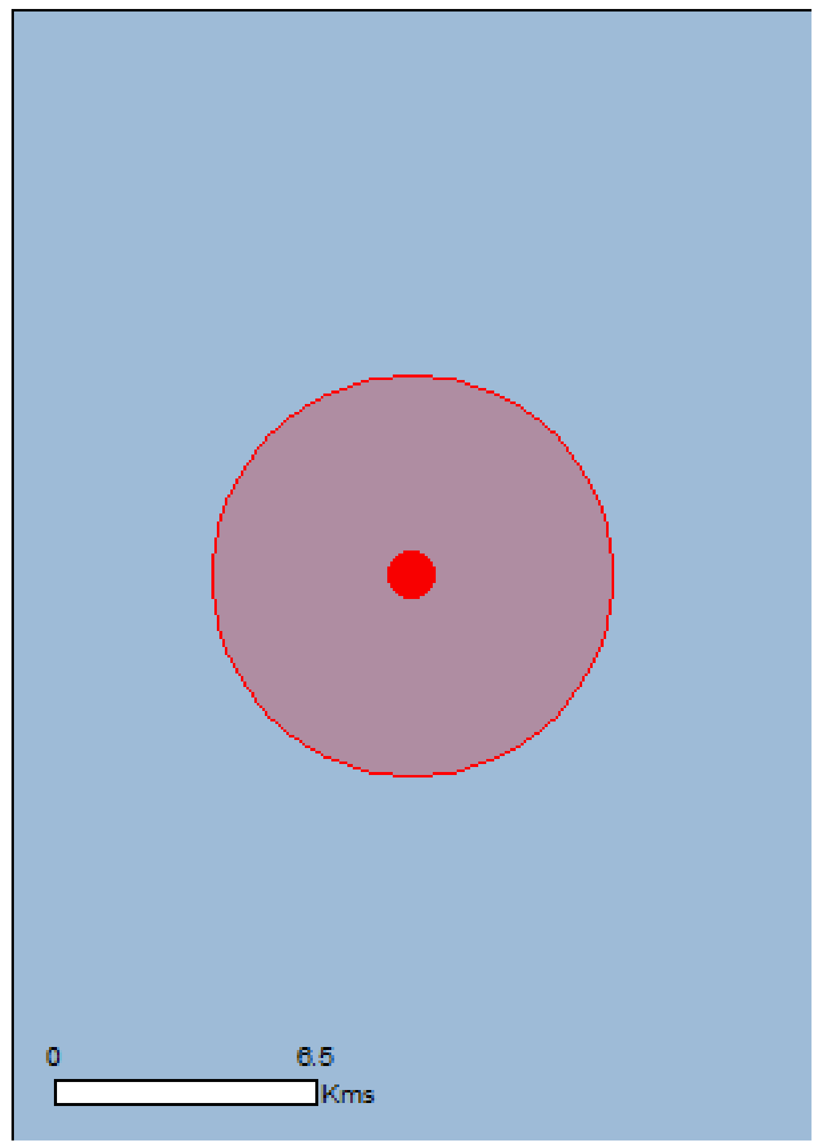
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

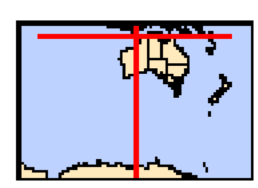
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 27/02/19 08:09:05



Coordinates

Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	19
Listed Migratory Species:	31

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	59
Whales and Other Cetaceans:	22
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Fish		
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area

Name	Status	Type of Presence
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris		
Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Extra Information

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-13.78637 123.31754

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Australian Government

Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

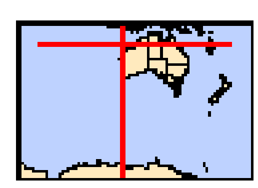
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/09/19 15:03:57

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	2
National Heritage Places:	6
Wetlands of International Importance:	5
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	100
Listed Migratory Species:	99

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	9
Commonwealth Heritage Places:	18
Listed Marine Species:	195
Whales and Other Cetaceans:	34
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	1
Australian Marine Parks:	31

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	63
Regional Forest Agreements:	None
Invasive Species:	38
Nationally Important Wetlands:	15
Key Ecological Features (Marine)	20

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Shark Bay, Western Australia	WA	Listed place
The Ningaloo Coast	WA	Listed place
The West Kimberley	WA	Listed place
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place
Historic		
Dirk Hartog Landing Site 1616 - Cape Inscription Area	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Eighty-mile beach	Within Ramsar site
Hosnies spring	Within Ramsar site
Roebuck bay	Within Ramsar site
The dales	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Accipiter hiogaster natalis		
Christmas Island Goshawk [82408]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Chalcophaps indica natalis Christmas Island Emerald Dove, Emerald Dove (Christmas Island) [67030]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren [26004]	Vulnerable	Species or species habitat likely to occur within area
Ninox natalis Christmas Island Hawk-Owl, Christmas Boobook [66671]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Turdus poliocephalus erythropleurus Christmas Island Thrush [67122]	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Fish		
Milyeringa veritas		
Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum		
Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies		
Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur		
Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat likely to occur within area
Bettongia penicillata ogilbyi		
Woylie [66844]	Endangered	Species or species habitat known to occur within area
Conilurus penicillatus		
Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Crocidura trichura		
Christmas Island Shrew [86568]	Critically Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isoodon auratus auratus		
Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies		
Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus dorreae		
Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Lagostrophus fasciatus fasciatus Banded Hare-wallaby, Merrnine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat may occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Perameles bougainville bougainville Western Barred Bandicoot (Shark Bay) [66631]	Endangered	Species or species habitat known to occur within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat known to occur within area
Pipistrellus murrayi Christmas Island Pipistrelle [64383]	Critically Endangered	Species or species habitat known to occur within area
Pteropus natalis Christmas Island Flying-fox, Christmas Island Fruit-bat [87611]	Critically Endangered	Roosting known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Plants		
Asplenium listeri Christmas Island Spleenwort [65865]	Critically Endangered	Species or species habitat known to occur within area
Keraudrenia exastia Fringed Keraudrenia [66301]	Critically Endangered	Species or species habitat known to occur within area
Pneumatopteris truncata fern [68812]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Tectaria devexa [14767]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus egeriae Christmas Island Blue-tailed Skink, Blue-tailed Snake-eyed Skink [1526]	Critically Endangered	Species or species habitat likely to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Cyrtodactylus sadleiri Christmas Island Giant Gecko [86865]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink [64483]	Endangered	Species or species habitat known to occur within area
Emoia nativitatis Christmas Island Forest Skink, Christmas Island Whiptail-skink [1400]	Critically Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lepidodactylus listeri Christmas Island Gecko, Lister's Gecko [1711]	Critically Endangered	Species or species habitat known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Ramphotyphlops exocoeti Christmas Island Blind Snake, Christmas Island Pink Blind Snake [1262]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Breeding likely to occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to

Name	Threatened	Type of Presence
		occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur

Name	Threatened	Type of Presence
		within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat known to occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Christmas Island National Park
Defence - BROOME TRAINING DEPOT
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - NORFORCE DEPOT - DERBY
Defence - RAAF BASE CURTIN
Defence - YAMPI SOUND TRAINING AREA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Christmas Island Natural Areas	EXT	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Yampi Defence Area	WA	Listed place
Indigenous		
Oombalai Area	WA	Within listed place
Historic		
Administrators House Precinct	EXT	Listed place
Bungalow 702	EXT	Listed place
Drumsite Industrial Area	EXT	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Industrial and Administrative Group	EXT	Listed place
Malay Kampong Group	EXT	Listed place
Malay Kampong Precinct	EXT	Listed place
Phosphate Hill Historic Area	EXT	Listed place
Poon Saan Group	EXT	Listed place
Settlement Christmas Island	EXT	Listed place
South Point Settlement Remains	EXT	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area

Name	Threatened	Type of Presence
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
[Limosa lapponica](#) Bar-tailed Godwit [844]		Species or species habitat known to occur within area
[Limosa limosa](#) Black-tailed Godwit [845]		Roosting known to occur within area
[Macronectes giganteus](#) Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
[Macronectes halli](#) Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat known to occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat known to occur within area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
[Numenius minutus](#) Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
[Numenius phaeopus](#) Whimbrel [849]		Roosting known to occur within area
[Pandion haliaetus](#) Osprey [952]		Breeding known to occur within area
[Papasula abbotti](#) Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
[Phaethon lepturus](#) White-tailed Tropicbird [1014]		Breeding known to occur within area
[Phaethon lepturus fulvus](#) Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
[Phaethon rubricauda](#) Red-tailed Tropicbird [994]		Breeding known to occur within area
[Philomachus pugnax](#) Ruff (Reeve) [850]		Roosting known to occur within area
[Pluvialis fulva](#) Pacific Golden Plover [25545]		Roosting known to occur within area
[Pluvialis squatarola](#) Grey Plover [865]		Roosting known to occur within area
[Pterodroma macroptera](#) Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
[Pterodroma mollis](#) Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Puffinus assimilis		
Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Puffinus carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus pacificus		
Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae		
Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna albifrons		
Little Tern [813]		Breeding known to occur within area
Sterna anaethetus		
Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis		
Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii		
Crested Tern [816]		Breeding known to occur within area
Sterna caspia		
Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii		
Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata		
Sooty Tern [794]		Breeding known to occur within area
Sterna nereis		
Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella		
Australian Pratincole [818]		Roosting known to occur within area
Sula dactylatra		
Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster		
Brown Booby [1022]		Breeding known to occur within area
Sula sula		
Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri		
Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta		
Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys sculptus Sculptured Pipefish [66197]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish,		Species or species

Name	Threatened	Type of Presence
Network Pipefish [66200]		habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Cosmocampus maxweberi Maxweber's Pipefish [66209]		Species or species habitat may occur within area
Doryrhamphus baldwini Redstripe Pipefish [66718]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus macrorhynchus Whiskered Pipefish, Ornate Pipefish [66222]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Halicampus mataafae Samoan Pipefish [66223]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippichthys spicifer Belly-barred Pipefish, Banded Freshwater Pipefish [66232]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area

Name	Status	Type of Presence
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Christmas Island	EXT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Cartier Island	Sanctuary Zone (IUCN Ia)
Dampier	Habitat Protection Zone (IUCN IV)
Dampier	Multiple Use Zone (IUCN VI)
Dampier	National Park Zone (IUCN II)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Oceanic Shoals	Habitat Protection Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)
Roebuck	Multiple Use Zone (IUCN VI)
Shark Bay	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Airlie Island	WA
Bardi Jawi	WA
Barrow Island	WA
Bedout Island	WA
Bernier And Dorre Islands	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Broome Bird Observatory	WA
Broome Wildlife Centre	WA
Browse Island	WA
Bundegi Coastal Park	WA
Cape Range	WA
Coulomb Point	WA
Dambimangari	WA
Dirk Hartog Island	WA
Jurabi Coastal Park	WA
Karajarri	WA
Lacepede Islands	WA
Lesueur Island	WA
Locker Island	WA
Low Rocks	WA
Lowendal Islands	WA
Mitchell River	WA
Montebello Islands	WA
Muiron Islands	WA
Murujuga	WA
North Turtle Island	WA
Nyangumarta Warrarn	WA
Prince Regent	WA

Name	State
Round Island	WA
Serrurier Island	WA
Swan Island	WA
Tanner Island	WA
Unnamed WA26400	WA
Unnamed WA28968	WA
Unnamed WA36907	WA
Unnamed WA36909	WA
Unnamed WA36910	WA
Unnamed WA36913	WA
Unnamed WA36915	WA
Unnamed WA37168	WA
Unnamed WA37338	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA40877	WA
Unnamed WA41080	WA
Unnamed WA41775	WA
Unnamed WA44665	WA
Unnamed WA44669	WA
Unnamed WA44672	WA
Unnamed WA44673	WA
Unnamed WA44674	WA
Unnamed WA44677	WA
Unnamed WA51105	WA
Unnamed WA51162	WA
Unnamed WA51497	WA
Unnamed WA51583	WA
Unnamed WA51617	WA
Unnamed WA51932	WA
Unnamed WA52354	WA
Uunguu	WA
Wilinggin	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Gallus gallus Red Junglefowl, Domestic Fowl [917]		Species or species habitat likely to occur within area
Lonchura oryzivora Java Sparrow [59586]		Species or species habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus exulans Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Cylindropuntia spp.		
Prickly Pears [85131]		Species or species habitat likely to occur within area
Dolichandra unguis-cati		
Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat may occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lycodon aulicus		
Wolf Snake, Common Wolf Snake, Asian Wolf Snake [83178]		Species or species habitat likely to occur within area
Lygosoma bowringii		
Christmas Island Grass-skink [1312]		Species or species habitat likely to occur within area
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
"The Dales", Christmas Island	EXT
Ashmore Reef	EXT
Big Springs	WA
Bunda-Bunda Mound Springs	WA
Cape Range Subterranean Waterways	WA
De Grey River	WA
Eighty Mile Beach System	WA
Hosine's Spring, Christmas Island	EXT
Mermaid Reef	EXT

Name	State
Mitchell River System	WA
Prince Regent River System	WA
Roebuck Bay	WA
Shark Bay East	WA
Willie Creek Wetlands	WA
Yampi Sound Training Area	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Carbonate bank and terrace system of the Van	North
Pinnacles of the Bonaparte Basin	North
Shelf break and slope of the Arafura Shelf	North
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Pinnacles of the Bonaparte Basin	North-west
Seringapatam Reef and Commonwealth waters in	North-west
Wallaby Saddle	North-west
Ancient coastline at 90-120m depth	South-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west
Western rock lobster	South-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-14.26314 100.97127,-9.8201 101.10456,-9.10922 102.59298,-8.28726 103.63709,-8.0651 105.36988,-8.10953 107.14709,-8.08732 109.39083,-8.08732 110.36829,-8.3539 111.19026,-8.22061 112.03443,-8.30947 113.3007,-8.48719 114.43367,-8.55384 115.41114,-7.95403 115.85544,-8.3539 116.01095,-8.66491 116.32196,-8.82042 116.8107,-8.7982 118.05475,-8.70934 118.76563,-8.15396 119.20994,-8.02067 120.00968,-8.3539 120.27627,-8.66491 121.4981,-8.62048 122.58664,-8.3539 123.27531,-8.10953 125.18582,-8.04289 126.80753,-8.02067 128.02936,-8.04289 128.87354,-8.88707 129.27341,-9.62017 129.62886,-9.86453 130.18424,-10.37548 129.80658,-10.64206 129.27341,-11.55289 129.18455,-12.06384 129.29563,-12.46371 129.56221,-13.99656 129.09569,-13.88548 128.42924,-13.86327 127.11854,-14.70744 125.58569,-15.3739 125.31911,-15.57384 124.87481,-16.3958 124.76373,-16.66238 124.16392,-17.16723 124.11563,-17.79535 123.56411,-17.35105 123.36418,-16.79567 122.76437,-17.10668 122.34228,-18.46181 122.52,-18.75061 121.9424,-19.75029 121.27595,-20.12795 118.78785,-20.48339 117.92146,-20.59447 116.94399,-20.83883 115.58886,-21.59415 115.18899,-21.99402 113.745,-23.19364 113.4562,-24.882 113.03412,-27.0813 113.25627,-27.83662 113.3007,-27.70333 113.07855,-28.23649 112.7231,-28.12541 111.39019,-27.68111 111.32355,-27.74776 112.58981,-27.03687 112.83418,-26.32598 112.45652,-26.48149 111.23469,-25.70396 110.54602,-25.99276 110.14614,-25.81503 109.72405,-25.08193 110.41272,-24.90421 111.41241,-24.10447 112.16772,-23.08257 111.56791,-22.14953 111.34576,-21.48307 111.47905,-20.90548 111.2569,-19.97244 111.34576,-19.52814 111.23469,-19.26156 111.8345,-18.95054 112.10108,-18.17301 112.10108,-17.92864 111.03475,-18.21744 110.70152,-18.72839 109.70184,-18.37295 109.03538,-17.23997 108.72437,-17.30662 108.48,-16.32915 107.52475,-16.61795 106.88051,-16.64016 105.56981,-17.08447 105.05886,-16.64016 104.85893,-15.61827 105.36988,-15.95149 104.61456,-15.84042 104.03697,-16.21808 103.215,-16.01814 102.59298,-15.92928 101.85988,-14.97403 101.23785,-14.26314 100.97127

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-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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Please feel free to provide feedback via the Contact Us page.

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